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LEGUMES OF THE NORTH-CENTRAL STATES: GALEGEAE[1]

Stanley Larson Welsh

INTRODUCTION

The Galegeae constitute a tribe of legumes whose members possess pinnately compound leaves with entire leaflets, and 10 stamens (usually diadelphous) with equal anthers. They lack the various specialized characters which are attributed to the other diadelphous tribes of the Leguminosae. Most of the genera are best represented in temperate regions. The members are of minor economic importance. A few are used as ornamentals or windbreak plantings (Caragana, Halimodendron, Robinia), others are secondarily important as weeds (Glycyrrhiza, Sesbania), and still others are poisonous plants of range land pastures (members of Astragalus and Oxytropis).

The tribe has been variously treated by North American students of the legumes. The introduced taxa have essentially been ignored. There has been much disagreement in the interpretations of native entities. Generic and specific delimitations have varied from author to author and many name changes have been proposed.

This study is an investigation of the taxonomy and biogeography of the Galegeae in the north-central states. In some aspects it is preliminary since a definitive solution of a number of problems will require detailed and lengthy investigations of individual species complexes. In general the treatment is concerned with plants at the species level, but in certain instances infraspecific taxa have been considered. The writer has attempted to present a consistent and orderly interpretation of the Galegeae of immediate usefulness to those concerned with problems of classification; he has likewise attempted to point the way for further studies.

The responsibility of a taxonomist to nomenclature is presumed to be secondary. Unfortunately, man-made problems sometimes approach the biological ones in complexity. An effort has been made to put the nomenclature (of the entities studied) in order, and this has indeed been one of the major endeavors of this study.

This paper is one of a series dealing with the legumes of the north-central states. Previous treatments were written by Isely and have dealt with the tribes Loteae and Trifolieae (1951), Hedysareae (1955), and the subfamilies Mimosoideae and Caesalpinoideae (1958).

HISTORICAL ACCOUNT

As here presented, the history of the Galegeae in our region is divided into three categories: exploration, compilation, and taxonomy. The

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chronology of the three categories, of course, overlaps and all three types of investigation are being carried on at the present time. However, the exploratory phase of botanical research is basic to the development of those to follow and commonly precedes them by a number of years.

Exploration

A few of our species had been described by Linnaeus as early as 1753. These represented plants of wide distribution and most of them were collected adjacent to populated areas of the eastern United States and Canada. However, most of the members of the Galegeae which are native to our region remained unknown until after the turn of the nineteenth century.

The Lewis and Clark expedition (1804-1806), yielding Astragalus tenellus Pursh from the botanical collection, stands as the real starting point for the exploration of the Galegeae in the north-central states. More important, this epic journey acted as a stimulus for further work. During 1810 and 1811 Thomas Nuttall and John Bradbury collected along the upper Missouri. Among their finds were such species as Astragalus ceramicus (Psoralea longifolia), A. crassicarpus, A. gilviflorus (A. triphyllus), A. missouriensis, A. gracilis (Dalea parviflora), and Oxytropis lambertii. In 1819 Nuttall journeyed from Philadelphia to the "Arkansas" region. There "on the Plains of the Arkansas" he collected Astragalus trichocalyx. Later Nuttall accompanied the Weyeth expedition to the Pacific Northwest. He was thus enabled to traverse the north-central states and to collect a number of previously undescribed species, among them were Oxytropis multiceps, O. sericea, O. viscida, Astragalus plattensis, A. spatulatus (Homalobus caespitosus), A. tegetarius (Kentrophyta montana), and A. striatus.

Meanwhile, botanical exploration was under way in Canada and in the Pacific Northwest. Species whose ranges extended from those regions into the north-central states were being discovered and described. Dr. John Richardson and Mr. Drummond accompanied Sir John Franklin on his journey to the Polar Sea in search for a northwest passage during the years 1819-1821 and again from 1823-1825. They collected Astragalus aboriginorum, A. bisulcatus (Phaca bisulcata), A. lotiflorus, and A. vexilliflexus (A. pauciflorus). David Douglas collected in the Pacific Northwest during 1825 and 1826 and then traversed the continent to Hudson Bay. The Douglas collections yielded such species as Astragalus agrestis, A. drummondii, A. flexuosus, A. pectinatus, and A. purshii.

In 1839 C.A. Geyer, who traveled with the Nicollet expedition, collected plants in the region of St. Louis and northward to North Dakota. By that time most of the plants belonging to the Galegeae of the region had already been described.

With a few exceptions the period of exploration now entered a second phase which has continued to the present time; that of establishing the geographic distribution and variability of the species discovered and described by others.

During the 1850's and 60's the collections of Hayden, Suckley, Donelson, Mullan, Hall and Harbour, and Parry added to the general botanical

knowledge of the region. Other individuals were at work in more specific areas in the various states.

Towards the end of the nineteenth century, there was renewed activity in collecting and in the quest for botanical knowledge. This activity has continued to the present. It is beyond the scope of the present study to list the names of all students who have contributed to this phase of plant taxonomy. However, an attempt will be made to enumerate those whose efforts have been especially outstanding. O.A. Stevens has studied the flora of North Dakota for fifty years. His excellent specimens are deposited in the herbarium of the U. S. National Museum and in the herbarium of the North Dakota State Agricultural College. W.H. Over, a naturalist from South Dakota, has contributed much to the floristic knowledge of that state. Perhaps the most complete collection of the Nebraska members of the Galegeae is that of J. M. Bates, an amateur botanist who collected widely over that state for many years. His specimens are largely deposited in the herbarium of the University of Nebraska State Museum. E.J. Palmer, J.A. Steyermark, B.F. Bush, and others have contributed enormous numbers of plant specimens from the state of Missouri. In Iowa the collections of B. Shimek, L.H. Pammel, and A. Hayden are among the most important. E.P. Sheldon and J.W. Moore have worked extensively in Minnesota. In Wisconsin N.C. Fassett added much to the knowledge of legumes.

Thus, botanical exploration has persisted to the present time, and with much information still to be gained it will remain an important phase of botany in the future.

Compilation

The compilative phase of botany follows the work of the collector. In 1814 Pursh published the Flora Americae Septentrionalis which contains the original descriptions of many species of plants native to the north-central states. The Genera of North American Plants (1818) by Nuttall reviews the treatment of Pursh and contains a few original descriptions. The Flora Boreali-Americana (Vol. 1, 1829-1834) by Hooker contains many new species based largely on the collections of Richardson, Drummond, and Douglas. Torrey and Gray's Flora of North America (1838) possibly contains more original descriptions of the galegaceous plants of the north-central states than any other single publication. Most of the species are based on materials collected by Nuttall.

Subsequent to the pioneer compilations discussed above many other publications have appeared in which the north-central states legumes have been treated. These may be classified into three categories on the basis of their scope; regional floras, state and local floras and check-lists, and treatments of legumes specifically. Among the former are the works by Eaton and Wright (1840), Gray (Manual of Botany, 1848 to 1950 in eight editions and under various authors), Britton and Brown (1897), Britton (1901, 1905), Rydberg (1932), Sargent (1933), Bailey (1949), Rehder (1951) and Gleason (1952).

The regional floras are exceeded in numbers by the local and state floras and lists. Outstanding among these are MacMillan (1892), Britton et al. (1894), Rydberg (1895, 1896), Beal (1904), Peterson (1923), McIntosh

(1931), Over (1932), Palmer and Steyermark (1935), Winter (1936), Deam (1940), Gates (1940), Jones (1945), Moore and Tryon (1946), and Jones and Fuller (1955).

The Leguminosae have been treated separately in three states; in Wisconsin by Fassett (1939), in Iowa by Fox (1945), and in Illinois by Gambill (1953).

Taxonomy

The nature of the work involved in the preparation of revisionary or monographic treatments is dependent upon the previous exploratory and compilative phases of botanical investigation. The first major taxonomic treatment of the Galegeae in North America is Gray's revision of Astragalus and Oxytropis (1864). Other important works on Astragalus include those by Watson (1871), Sheldon (1894), MacBride (1922), Jones (1923), Rydberg (1929b), Porter (1939), and Barneby (1947a, 1947b, 1947c). Important works on Oxytropis include the revisions by Gray (1884) and Barneby (1952). The genus Tephrosia has been treated by Vail (1895), Britten and Baker (1900), and Wood (1949). Caragana was monographed by Komarov (1908). Robinia, Sesbania, and other genera of the Galegeae of North America were treated in Vol. 24 of the North American Flora by Rydberg (1924-1929).

Data from many other papers are reviewed with respect to the treatment of individual taxa.

MATERIALS AND METHODS

Taxonomic Investigations

Herbarium studies

Studies of herbarium material have formed the central core of the present work. Approximately ten thousand specimens were examined. The objectives of these investigations were: (1) to interpret better the taxonomic entities and the variability in constituent groups; (2) to provide accurate and consistent descriptions of the taxa; (3) to view the distribution of the taxa within the north-central states (in some cases to verify or reject previous reports of occurrence in this region); (4) to attempt to derive information on habitat and other useful data as the labels allowed.

The employment of herbarium material obviously possesses limitations as compared to field observations. In consequence, herbarium investigations have been supplemented by field studies as related below. Notwithstanding, field work is no substitute for thoroughgoing herbarium investigations. When one assembles hundreds of specimens (drawing on the field work of all previous investigators) from all parts of the range of a taxon, it is possible to obtain a picture of phenotypic and geographical characteristics that could be paralleled only by a life-time of field studies. Hence, this explains the emphasis on the laboratory phases of this investigation.

In the course of the herbarium examinations taxonomic criteria relating to size and shape were evaluated through measurements of plant

structures; features not easily subject to linear comparisons were subjected to critical examination. Parts less than 10 mm long were measured with the aid of a Spencer low-power binocular microscope equipped with 1X, 2X, and 3X objectives and 9X wide field oculars. One ocular was furnished with a micrometer disc which had been calibrated with a stage micrometer. All other measurements were made with an ordinary 30 cm rule graduated in millimeters.

Measurements of flowers were made from the base of the calyx to the tip of the banner, or to the tip of the wings if they exceeded the banner. Pod length was determined from the point of insertion within the calyx to the apex of the pod. The length of the stipe (where present) was included in the pod measurements, but the style length was excluded. The calyx tube length was assayed from the point of insertion of the pedicel to the base of the sinus between the teeth and the calyx teeth were measured from the base of the sinus to the tip of the dentation.

The information on collection locality was recorded for each herbarium sheet examined. Where only towns were designated, their county locations were checked either on state highway maps or in the Hammond World Atlas. The distribution of each species was plotted on U.S. Department of Agriculture base maps on which the counties were outlined in blue ink.

When habitat data or information on the habit, flower color, or other peculiarities of a specimen was tabulated on the label, the information was recorded. These data were used in association with that derived from earlier publications and field experience to characterize as closely as possible the habitat, growth characteristics, etc., of each species.

The herbaria consulted during the course of this study are listed below. Preceding each is a key letter or letters by which the institution is identified. The key letters are the standardized abbreviations given by Lanjouw and Stafleu (1959).

F	Chicago Natural History Museum
GH	Gray Herbarium, Harvard University
ISC	Iowa State University
K	Royal Botanic Gardens, Kew
MICH	University of Michigan
MIN	University of Minnesota
MO	Missouri Botanical Garden
NDA	North Dakota Agricultural College
NEB	University of Nebraska State Museum
NY	New York Botanical Garden
OXF	Fielding Herbarium, Oxford
PH	Academy of Natural Sciences, Philadelphia
RM	Rocky Mountain Herbarium, University of Wyoming
RSA	Rancho Santa Ana Botanic Garden
SDU	University of South Dakota
WS	State College of Washington

Since the present study includes the cultivated plants in addition to those which are native, a special effort was made to examine pertinent herbarium material. The search was disappointing because botanists

have generally concerned themselves with native plants or with escaped, cultivated forms.

Field studies

Investigations were carried out in the field during May, June, and July of 1958 and during April, May, and June of 1959. During the 1958 season collections were made in Iowa, Kansas, Nebraska, South Dakota, North Dakota, and Minnesota. The states of Nebraska, South Dakota, North Dakota, and Minnesota were revisited during the 1959 season, and additional trips were made to Missouri and Illinois. Herbarium specimens were prepared from field material. The plants were dried in presses suspended over electric drying units. The specimens are deposited in the herbarium of Iowa State University.

During the course of the field work it was possible to study living material of the majority (37 of 49) of the species of the north-central states Galegeae. Notes were taken especially on those features which are difficult to determine from dried materials. For example, the flower color, which tends to change on drying, was recorded. Likewise, consideration was given to stature, habitat, and population and geographic variability.

Special emphasis was placed on the collection of cultivated plants. Residential landscape plantings, city parks and gardens, and wind-break and hedge plantings were visited on every possible occasion. This resulted in many additional specimens of cultivated legumes and considerable data concerning their distribution and variability.

Nomenclatural Investigations

In order to present a consistent and usable treatment for subsequent students, the author has attempted to determine the correctness of name usage of all taxa studied and to list correctly assigned synonyms. The original descriptions of all names (both names employed and synonyms) have been seen except: (1) those names in Caragana and Halimodendron in which the literature was unavailable; (2) certain horticultural variants of Robinia (forms, varieties, and a few "species"). With respect to the exceptions noted above the names not verified by the writer have been indicated by the term "fide" followed by the name of the author whose treatment has been followed.

As far as available, type specimens or photographs of type material have been studied to verify interpretation from descriptions. Examination of such material has been indicated by an asterisk (*) preceding the name. Types of several species have been studied by previous workers. In those instances in which verification is based upon the interpretation of previous authors the name is indicated by "fide" followed by the author's name.

Varietal and other infraspecific synonyms are included in most species. However, in some Astragali and Oxytropi in which the number of synonyms is large, the synonymy is restricted to the entities occurring in the north-central states.

TAXONOMIC AND NOMENCLATURAL TREATMENT

Galegeae

Herbs, shrubs or trees. Leaves stipulate, odd-pinnate or even-pinnate, rarely palmately trifoliolate or simple; stipels present or lacking; leaflets entire. Inflorescence monopodial, of axillary racemes or rarely sympodial (Tephrosia). Calyx campanulate, cylindric, or turbinate, 5-toothed or 5-lobed. Corolla papilionaceous, pink-purple, yellow, ochroleucous, or whitish. Stamens 10, diadelphous (in ours), the anthers alike. Pods variously shaped, usually dehiscent.

The Galegeae, one of the major tribes of the Leguminosae, consists of some 50 to 60 genera of plants of wide geographic distribution. The greater number of the genera are comprised of temperate plants; a few are best represented in tropical and subtropical regions. Approximately 30 genera and 500 species occur in North America. Of these, 8 genera and 49 species are known from the north-central states.

The Galegeae represent more or less generalized legumes which lack the specialized characters of some of the other tribes. Many of the genera have been assigned to this group only on a negative basis—i.e. because they lack the definitive features which would associate them with any of the more clearly defined tribes. The group possibly contains several phyletic lines and is therefore difficult to define concisely.

Such genera as Astragalus, Oxytropis, Caragana, Halimodendron, and Robinia seem to constitute a natural group, at least morphologically, and possibly in an evolutionary sense. The other genera present in the north-central states (Tephrosia, Glycyrrhiza, Sesbania) appear to represent different phyletic lines. They are probably not closely related to each other or to the genera discussed above. Tephrosia, with its collar- or cup-shaped receptacle at the base of the ovary within the staminal sheath, would possibly be better included in the Phaseoleae. However, since most of the members of the Phaseoleae tend to be woody climbers, Tephrosia is herein retained with the Galegeae. The glandular punctate condition of the herbage of Glycyrrhiza and its indehiscent pods might indicate an affinity with the members of the Psoraleae. However, the pods of Glycyrrhiza are many-seeded as opposed to the usually one-seeded pods of the Psoraleae; again it seems too early to break with tradition. The partitioned pods of Sesbania may demonstrate affinities with some of the Hedysareae, a group with a single specific character (the loment), which may have been derived from several phyletic lines.

The term Galegeae, as herein employed, contains those genera traditionally ascribed to it with the exception of Wisteria. The presence of the collar- or cup-shaped receptacle at the base of the ovary within the staminal sheath in conjunction with the woody, twining habit of the members of this genus suggest a closer relationship with the Phaseoleae.

Because of the limited number of species and genera present within the bounds of the region covered by this paper it is not feasible to evaluate generic relationships and delimitations.

Key to the Genera

1. Leaves even-pinnate.
   2. Plants perennials, shrubs or small trees; leaflets 4-12.
      3. Leaflets 4, remote; inflorescence 1- to 3-flowered; flowers pink-purple; pods inflated, stipitate. Halimodendron
      3. Leaflets 4-12 (if 4 then fascicled); inflorescence 1-flowered; flowers yellow; pods linear, sessile. Caragana
   2. Plants annual, herbaceous; leaflets 24-70. Sesbania
1. Leaves odd-pinnate.
   4. Plants woody, shrubs or trees. Robinia
   4. Plants herbaceous.
      5. Racemes terminal; if also lateral, then arising opposite the leaves. Tephrosia
      5. Racemes axillary.
         6. Foliage glandular-punctate; pods covered with hooked spines. Glycyrrhiza
         6. Foliage not glandular-punctate; pods glabrous or merely pubescent.
            7. Keel-tip extended as a beak; pods with the upper (ventral) suture intruded; plants scapose. Oxytropis
            7. Keel-tip blunt; pods with sutures various; plants usually not scapose. Astragalus

ASTRAGALUS L.

Astragalus L. Sp. Pl. 755. 1753.
Phaca L. Sp. Pl. 755. 1753.
Tium Medic. Vorles. Kurpfalz. Physik.-Oekon. Ges. 2:373. 1787.
Colutea sensu Poir. ex Lam., Encyc. Suppl. 1:561. 1810. pro parte.
Dalea sensu Pursh Fl. Am. Sept. 474. 1814. pro parte.
Ervum sensu Pursh Fl. Am. Sept. 739. 1814. pro parte.
Psoralea sensu Pursh Fl. Am. Sept. 741. 1814. pro parte.
Orobus sensu Nutt. Gen. 2:95. 1818. pro parte.
Physondra Raf. Atl. Jour. 145. 1832.
Homalobus Nutt. ex T. and G., Fl. N. Am. 1:350. 1838.
Kentrophyta Nutt. ex T. and G., Fl. N. Am. 1:353. 1838.
Tragacantha Kuntze Rev. Gen. 2:942. 1891.
Orophaca (T. and G.) Britt. ex Britt. and Brown, Ill. Fl. 2:306. 1897.
Geoprumnon Rydb. ex Small, Fl. SE. U.S. 615. 1903.
Holcophacos Rydb. ex Small, Fl. SE. U.S. 618. 1903.
Xylophacos Rydb. ex Small, Fl. SE. U.S. 619. 1903.
Atelophragma Rydb. Bull. Torrey Club 32:660. 1905.
Cnemidophacos Rydb. Bull. Torrey Club 32:663. 1905.
Ctenophyllum Rydb. Bull. Torrey Club 32:663. 1905.
Microphacos Rydb. Bull. Torrey Club 32:663. 1905.
Diholcos Rydb. Bull. Torrey Club 32:664. 1905.
Cytospora Lunell Am. Midl. Nat. 4:428. 1916.
Batidophaca Rydb. N. Am. Fl. 24:314. 1929.
Pisophaca Rydb. N. Am. Fl. 24:322. 1929.

Plants herbaceous, perennial (in ours), caulescent or acaulescent, ascending to erect, decumbent, or prostrate and mat-forming. Stipules connate or free, ovate to lanceolate or triangular-subulate. Leaves alternate, odd-pinnate, 5-plurifoliolate, rarely palmately, trifoliolate or simple; leaflets opposite or scattered, entire. Racemes axillary, sessile to long pedunculate, elongate or spike-like or congested and subcapitate. Flowers papilionaceous, the keel lacking a beak; stamens diadelphous. Calyx cylindric to campanulate, 5-toothed. Pods sessile or stipitate, straight or curved, variously compressed or inflated, papery, woody, or fleshy, dehiscent or indehiscent, glabrous or hairy, 1-celled, partially 2-celled, or completely 2-celled by the intrusion of the dorsal (lower) suture; both sutures prominent or the dorasl suture sulcate or both sutures sulcate.

The Astragali of the north-central states represent only a small part of a great complex which may contain as many as 1200 species. In North America the main body of the genus occurs in the southwestern part of the United States. The species which inhabit the plains and prairies appear largely to represent outliers of the genus from western North America. Perhaps a few may be regarded as relicts of a wider distribution in the past. None of the species are endemic to our region.

Classification

The genus Astragalus, with its diversity of forms, has been the subject of many investigations since the time of Linnaeus. It has been divided into numerous segregates by various authors. The most recent and comprehensive segregation is that of Rydberg (1929b) in the North American Flora. This work culminated more than three decades of publication and study by that author. It includes no less than 33 genera. More recent authors such as Porter (1939, 1945, 1951, 1954) and Barneby (1944, 1946, 1947a, 1947b, 1947c, 1951a, 1951b, 1956a, 1956b) have retained all of these segregates in the genus Astragalus.

However, if the Astragalus complex is to be regarded as a single genus it is desirable to divide it into sections to facilitate classification and as a method of postulating phylogenetic groups. The sections are then, to the extent that knowledge permits, comprised of related species. The authors of all major systems of classification (other than those following Rydberg) have recognized sectional names in Astragalus. Although there has been disagreement on the names of the sections and on the disposition of individual species there has been considerable consistency in the delimitation of the groups.

The generic segregates of Rydberg (as discussed above) largely correspond to the sectional delimitations as interpreted by Marcus Jones (1923) and Gray (1864). The species of Astragalus present in our region would be placed in 15 sections in Jones' system, 17 sections in Gray's system, and 15 segregate genera in Rydberg's system. Porter (1951) has used the Rydbergian generic names in the role of subgenera. Barneby, in his revisions of several sections, has followed the treatment of Jones.

The writer essentially follows Jones, not with a feeling that his work is complete, but because of the geographic limitations of the present study, his treatment seems to place north-central states species in more natural groups.

The following is a summary of the present treatment. Where the writer has disagreed with the interpretations of Jones, special note is made. Rydberg segregates are placed in parentheses () following the section name.

Homalobi (Homalobus, Kentrophyta): Plants of various vegetative aspects; mat-forming, decumbent, or erect. Flowers small; calyx campanulate. Pods 1-celled, straight, laterally compressed, dehiscent; the valves coiling in dehiscence. e.g. A. tenellus, A. spatulatus, A. vexilliflexus, A. tegetarius. Jones included A. sericoleucous in the Homalobi. However, its affinities appear to be with the Triphylli and it is included in that group in the present paper.

Triphylli (Orophaca): Plants caespitose, acaulescent. Leaves palmately trifoliolate. Herbage sericeous with malpighian hairs. Pods 1-celled, ovoid, tardily dehiscent. e.g. A. barrii, A. gilviflorus, A. hyalinus, A. sericoleucous.

Inflati (Phaca pro parte): Plants erect to prostrate; leaflets linear. Pods stipitate, much inflated, membranous, mottled. e.g. A. ceramicus.

Alpini (Atelophragma, Phaca pro parte): Plants decumbent to ascending or erect. Flowers small to moderate in size. Pods stipitate, 1-celled, spreading or pendulous; the sutures variously produced or inflexed as a partial partition. e.g. A. alpinus, A. americanus, A. aboriginorum.

Podo-sclerocarpi (Cnemidophacos): Plants erect or ascending. Leaflets linear. Pods 1-celled, sessile, fleshy, becoming woody at maturity, dehiscent. e.g. A. pectinatus.

Uliginosi (Astragalus pro parte, Phaca pro parte): Plants erect or ascending. Flowers of moderate size, yellowish; calyx cylindric or short-cylindric. Pods various in shape and septation, sessile, fastigate, tardily dehiscent. e.g. A. canadensis, A. cooperi. The retention of A. cooperi with the Uliginosi is largely a matter of convenience. It may well represent a distinct section.

Hypoglottides (Astragalus pro parte): Plants decumbent to erect. Flowers erect in subcapitate racemes. Pods 2-celled, erect, tardily dehiscent. e.g. A. striatus, A. agrestis.

Lotiflori (Batidophaca): Plants caespitose; stems poorly developed. Flowers variously colored; calyx campanulate. Pods 1-celled, ovoid-lanceolate; both sutures prominent, the ventral one acute, the dorsal flattened, tardily dehiscent. e.g. A. lotiflorus.

Flexuosi (Pisophaca, Microlobus): Plants decumbent to erect. Flowers small, purplish; calyx campanulate. Pods sessile, 1-celled, dorsally compressed, both sutures prominent. e.g. A. flexuosus, A. gracilis.

Agrophylli (Xylophacos): Plants caespitose, acaulescent. Leaves plurifoliolate. Flowers moderate to large; purplish or yellowish; calyx cylindric. Pods 1-celled, ovoid to oblong, dehiscent or tardily so. e.g. A. missouriensis, A. purshii.

Mollissimi (Astragalus pro parte): Plants caespitose; stems short. Flowers large, greenish-purple, calyx cylindric. Pods sessile, 2-celled, oblong, curved, dehiscent. e.g. A. mollissimus.

Sarcocarpi (Geoprumnon): Plants caespitose, decumbent to ascending.

Flowers large, purplish or yellowish; calyx cylindric. Pods sessile or subsessile, 2-celled, fleshy, ovoid to ovoid-lanceolate, indehiscent. e.g. A. crassicarpus, A. plattensis, A. tennesseensis, A. trichocalyx.

Bisulcati (Diholcos): Plants caespitose, ascending to erect. Flowers moderate in size, purplish (rarely other colors); calyx short-cylindric. Pods stipitate, 1-celled, oblong, with two longitudinal furrows on the ventral surface, e.g. A. bisulcatus.

Galegiformes (Tium): Plants caespitose; ascending to erect. Flowers moderate in size, yellowish; calyx cylindric. Pods stipitate, 1-celled, oblong, triquetrous in cross-section. e.g. A. racemosus, A. drummondii.

Hamosi (Holcophacos): Plants caespitose; decumbent to erect. Flowers small, purplish; calyx campanulate. Pods sessile, 1-celled (in ours), oblong, curved. e.g. A. distortus. Rydberg also recognized a genus Hamosa but excluded A. distortus from it on the basis of the 1-celled pods of A. distortus.

Taxonomic criteria

The stature or habit of growth, leaflet number and form, vesture, shape and mode of attachment of stipules, and the nature of the underground parts are the most useful of the vegetative characteristics. The correlation of several vegetative specializations in the same species or species-group facilitates identification. For example, the acaulescent nature of the Triphylli is associated with the palmately trifoliolate leaves and malpighian pubescence. However, more generalized astragali frequently lack specific vegetative characters and other features must be employed for their identification.

The vegetative features of the species of Astragalus herein treated have been characterized more thoroughly than in most previous studies. As far as possible, vegetative characters have been employed as major diagnostic criteria, particularly in the key. In many instances, however, it has been necessary to fall back upon floral and fruit structure.

Calyces of two main types occur in our plants. The tube of a cylindric calyx commonly possesses parallel sides. The so-called campanulate calyx tapers from the end of the tube to the pedicel. Short calyces are frequently campanulate and the longer ones are cylindric. Frequently all the members of a given section will be either cylindric or campanulate, but in a few instances (e.g. Triphylli) both calyx types are present.

Flower color is a good diagnostic character for the separation of plants in living condition. However, it is of limited usefulness in the examination of dried specimens since the differential shades are frequently impossible to distinguish. The keel-tip occasionally fades so that it is not possible to recognize whether it is maculate or immaculate, but this part commonly retains some shade of color even though the remainder of the flower is completely faded.

The vesture of the herbage (or more rarely of the pods and petals) consists of two types. The most common form is that of simple, basally attached trichomes. The second type consists of hairs which are pointed at both ends and attached between the two points (malpighian or dolabriform trichomes). Of the several species having malpighian hairs only those of A. racemosus are difficult to detect, because in that species the attachment of the hair is very near to one end.

The pods of Astragalus are diverse and they have constituted the principal feature on which systems of classification and keys for identification have ordinarily been based. The most distinctive pod characters are the degree of septation, the over-all shape, and the cross-sectional form. The presence or absence of a stipe and the vesture of the pods are secondary characters which are valuable in distinguishing individual species. The texture of the valves is difficult to define on an objective basis. A reasonably precise interpretation of terminology may, however, be achieved by comparison of different types of pods. Cross-sectional shape, a principal feature of some keys, is often difficult to determine in pressed specimens, especially if the pods are immature.

Phylogeny

The circumboreal distribution of Astragalus, plus the presence of a number of species in South America would seem to indicate that the genus is not of recent origin. Its distribution in the northern hemisphere, with population centers in the arid regions, can perhaps be rendered logical by relating it to events of the geologic past. It is possible that Astragalus was a component of the transboreal Arcto-Tertiary forest. With the change of climatic conditions the range of the forest elements shrank toward more equable regions. However, certain of the Astragali possibly became stranded in the arid regions where they have since become well established.

Astragalus appears to be closely related to Oxytropis and the two genera probably arose from common ancestral stock. They seem to have had a parallel development and some forms are strikingly similar.

There is a remarkable resemblance between the spiny, woody Astragali and members of Caragana. In the former, the leaf rachis may be persistent and the terminal leaflet reduced to a spine as in many species of Caragana. However, the vast majority of the Astragali are herbaceous; the leaf rachis is deciduous, and the terminal leaflet is very much evident. Thus, the woody forms have probably been secondarily derived and their similarity to Caragana is merely an example of parallel evolution. This does not rule out the possibility that the genera Astragalus and Caragana (and Halimodendron) have descended from some common ancestral prototype.

Evolution within Astragalus appears to have taken place in several directions. The most perceptible modifications have taken place in the pods, but vegetative specializations are apparent in several lines. In some cases the pods have remained more or less stable and the vegetative parts have become greatly modified. The converse may also be true. Sections such as the Galegiformes and the Bisulcati appear to be closely related. They differ primarily in pod structure.

The hypothetical primitive ancestor of modern Astragalus probably had several of the following characters; (1) plant body decumbent to erect with well developed stems; (2) leaves plurifoliolate; (3) leaflets oblong to oval or elliptic; (4) stipules connate; (5) racemes elongate and many-flowered; (6) flowers small and with campanulate calyces; (7) pods 1-celled, sessile, straight, laterally compressed, and dehiscent.

Vegetative characters and pod characters seem to have evolved more or less independently. The most radical vegetative modifications (e.g.

acaulescence, reduction of leaflet number, densely villous to lanose or densely strigose pubescence) appear to have evolved in response to their selective advantage in specialized habitats. Mat-forming plants occur in two different sections of north-central states Astragali (Triphylli, Homalobi). The species involved in these instances occupy more open or barren areas in the drier, upland prairie regions of the western part of our range. Other specializations are present in the Inflati and Pectinati in which the leaflets are long and linear.

The presence (among species) of common pod characters is possibly the best indication of relationships (though not infallibly so) in Astragalus. There are many combinations of pod characters possible and the probability of any given combination arising more than once seems slight. If this is the case then plants bearing similar pod-types are related and the closer the similarity the nearer the relationship.

Cytology

The various cytological studies in Astragalus indicate that the chromosome number is multibasic (Head 1955, Vilkomerson 1943, Ledingham 1957). In the north-central states Astragali, chromosome counts have been reported for fourteen species. The somatic number in three species is 16, in one species 32, in six species 22, and in four species 24; thus indicating the basic numbers of 8, 11, and 12.

Key to the Species of Astragalus

1. Leaves trifoliolate.
   2. Calyx cylindric; flowers whitish; inflorescence sessile.
      3. Corolla glabrous; plants flowering in May and early June. A. gilviflorus
      3. Corolla strigose; plants flowering in late June and July. A. hyalinus
   2. Calyx campanulate; flowers pink-purple, inflorescence pedunculate.
      4. Stipules villous; flowers 6-8 mm long. A. sericoleucus
      4. Stipules glabrous; flowers 9-13 mm long. A. barrii
1. Leaves not trifoliolate, usually with 5-many leaflets.
   5. Leaflets spinulose-tipped; plants mat-forming. A. tegetarius
   5. Leaflets not spinulose-tipped; plants various in habit.
      6. Leaves simple, unifoliolate, or rarely some of them trifoliolate.
         7. Leaves long-filiform, at least the upper reduced to linear phyllodia; plants from a rhizome; pods inflated and purple-mottled at maturity. A. ceramicus
         7. Leaves narrowly spatulate; plants acaulescent from a branching caudex; pods narrowly oblong. A. spatulatus
      6. Leaves pinnately compound with 5-many leaflets.
         8. Vesture consisting of malpighian hairs.
            9. Plants caespitose, low-growing; stems poorly developed.
               10. Calyx campanulate; plants strigulose to long-villous, greenish; flowers usually yellowish. A. lotiflorus

10. Calyx cylindric; plants silvery with appressed hairs; flowers purplish. A. missouriensis
9. Plants decumbent to erect; stems well developed.
11. Pods or ovaries distinctly stipitate; plants with a distinctive odor. A. racemosus
11. Pods or ovaries sessile; plants lacking a distinctive odor.
12. Flowers purplish; pods or ovaries strigose; plants blooming from late May to early July. A. striatus
12. Flowers yellowish; pods or ovaries glabrous; plants blooming from mid-July to September A. canadensis
8. Vesture consisting of basally attached trichomes.
13. Calyx cylindric.
14. Plants pulvinately caespitose; pods and herbage densely woolly-villous. A. purshii
14. Plants not pulvinately caespitose; pods and herbage various but not densely woolly-villous.
15. Pods and ovaries distinctly long-stipitate; pods reflexed.
16. Flowers purplish; pods bisulcate ventrally. A. bisulcatus
16. Flowers whitish or yellowish; pods triquetrous in cross-section.
17. Herbage loosely long-villous; plants lacking a distinctive odor. A. drummondii
17. Herbage strigose; plants with a distinctive odor. A. racemosus
15. Pods or ovaries sessile (rarely substipitate), usually not reflexed.
18. Flowers purplish; plants from a rhizome or caudex; calyx strigose or strigulose.
19. Plants long-villous throughout; pods curved, glabrous. A. mollissimus
19. Plants strigose to strigulose throughout; pods various, usually not curved.
20. Plants from a rhizome; calyx-teeth half as long as the tube; pods and ovaries pubescent.
21. Flowers erect; pods long-villous, oblong. A. agrestis
21. Flowers spreading; pods strigose, ovoid. A. plattensis
20. Plants from a caudex; calyx-teeth less than half as long as the tube; pods glabrous. A. crassicarpus
18. Flowers yellowish; the keel usually purple-tipped, calyx long-villous or lanose (strigulose in A. pectinatus); plants from a caudex.
22. Leaflets linear; plants from the western plains. A. pectinatus
22. Leaflets various but not linear; plants from Missouri, Illinois, or southeastern Kansas.

23. Plants villous; stipules foliaceous; pods villous. A. tennesseensis
23. Plants strigose; stipules not foliaceous; pods glabrous. A. trichocalyx
13. Calyx campanulate.
24. Stipules reflexed, foliaceous; plants in our area localized in the Black Hills. A. americanus
24. Stipules erect or spreading, not foliaceous; plants variously distributed.
25. Pods or ovaries distinctly stipitate (the stalk 1 mm or more in length).
26. Plants from a creeping rhizome; pods black-villous at maturity. A. alpinus
26. Plants from a caudex; pods glabrous at maturity or merely strigose.
27. Leaflets narrowly elliptic, acute; pods lunate; stipe at maturity 5-10 mm long. A. aboriginorum
27. Leaflets elliptic to oblong; obtuse, truncate or retuse (rarely acute); pods various; stipe 1-5 mm long.
28. Peduncles 1-4 cm long (occasionally borne in pairs), shorter than the raceme; flowers yellowish. A. tenellus
28. Peduncles 5-15 cm long (borne singly), seldom shorter than the racemes; flowers purplish. A. flexuosus
25. Pods or ovaries sessile within the calyx.
29. Flowers whitish or yellowish; pods ovoid-inflated; plants from Minnesota, Wisconsin, and Michigan. A. cooperi
29. Flowers usually purplish; pods linear-oblong, oblong, or boat-shaped; plants various in distribution.
30. Leaflets 17-27; pods 15-20 mm long, curved; dorsal suture sulcate; plants of eastern Kansas, Missouri, Iowa, and Illinois. A. distortus
30. Leaflets 7-17; pods 5-11 mm long, straight or boat-shaped; plants of the western great plains.
31. Calyx-teeth less than 1 mm in length; pods boat-shaped due to the inflection of the dorsal suture. A. gracilis
31. Calyx-teeth more than 1 mm in length; pods straight; both sutures prominent. A. vexilliflexus

Astragalus aboriginorum Richards. (Map 6. Plate I, Figs. A,B)

Astragalus aboriginorum Richards. ex Frankl., Jour. Bot. Append. 746. 1823.
Astragalus aboriginum Spreng. Syst. 4: Post. Cur. 288. 1827.
Phaca aboriginorum (Richards.) Hook. Fl. Bor. Am. 1:143. pl.56. 1830.
*Phaca glabriuscula Hook. Fl. Bor. Am. 1:144. 1830.

Astragalus vaginatus sensu authors, non A. vaginatus Pallas. 1880.
*Astragalus glabriusculus (Hook.) A. Gray var. major A. Gray Proc. Acad. Phila. 1863:60. 1864.
*Astragalus forwoodii S. Wats. Proc. Amer. Acad. 25:129. 1890.
Tragacantha aboriginum (Richards.) Kuntze Rev. Gen. 942. 1891.
Tragacantha glabriuscula (Hook.) Kuntze Rev. Gen. 945. 1891.
Astragalus richardsoni Sheld. Minn. Bot. Stud. 1:126. 1894.
Astragalus glabriusculus var. spatiosus Sheld. Minn. Bot. Stud. 1:156. 1894.
Astragalus aboriginum var. glabriusculus (Hook.) Rydb. Contr. U.S. Natl. Herb. 3:492. 1896.
Homalobus spatiosus (Sheld.) A. Heller. Cat. N. Am. Pl. ed.2. 7. 1900.
Homalobus glabriusculus (Hook.) Rydb. Mem. N.Y. Bot. Gard. 1:246. 1900.
Homalobus aboriginorum (Richards.) Rydb. Mem. N.Y. Bot. Gard. 1:246. 1900.
Homalobus aboriginum (Richards.) Rydb. ex Britton, Man. 554. 1901.
Atelophragma aboriginum (Richards.) Rydb. Bull. Torrey Club 32:660. 1905.
Atelophragma glabriusculum (Hook.) Rydb. Bull. Torrey Club 32:660. 1905.
Atelophragma forwoodii (S. Wats.) Rydb. Bull. Torrey Club 40:51. 1913.
Astragalus aboriginum var. fastigorum M.E. Jones Rev. Astrag. 135. 1923.
*Atelophragma wallowense Rydb. Bull. Torrey Club 55:122. 1928.

Stems 14-40 cm long, single to several from a branching caudex, erect or ascending, strigose to villous with simple hairs. Stipules 4-10 mm long, the lower ones connate-clasping, those above nearly free, the free ends triangular to lanceolate, strigose on the dorsal surface, acute. Leaves 3-8 cm long, short-pedicellate; leaflets 9-19, 9-23 (34) mm in length, 2-7 mm in width, glabrous to strigose above, strigose to villous below, narrowly elliptic, acute. Peduncles (2) 6-9 (15) cm, strigose. Bracts narrowly lanceolate, longer than the pedicels, strigose with black hairs. Racemes 2-11 cm, several-flowered, at first much contracted, elongating at maturity. Flowers 8-11 mm long, yellowish white, the keel purple-tipped. Calyx campanulate, strigose with black, simple hairs; tube 3-4 mm; teeth 1.5-4 mm, linear subulate. Pods 24-34 mm, lunate, papery, glabrous (rarely strigose when young), 1-celled, dehiscent; both sutures prominent; stipe 5-10 mm in length.

Astragalus glabriusculus, A. forwoodii, and Atelophragma wallowense are based on pubescence variants. However, the degree and position of pubescence is variable and many types occur in a single population. Indeed, plants with the pubescence characteristics of several of the segregates have been observed by the writer in a population on a single hillside near Spearfish, South Dakota. It is thus possible that the maintenance of those segregates, in any sense, is not justified. One is also led to suspect the validity of both A. lineare and A. heriotii which Rydberg (1928a) describes as differing largely in pubescence and leaflet shape.

Plate I. Astragalus aboriginorum, A. Section of stem with leaf and inflorescence. B. Fruit. Astragalus agrestis, C. Portion of plant with leaves and inflorescence. D. Fruit.

As only a fraction of the total range of this complex is included in the north-central states it is beyond the scope of this paper to present a definitive analysis of the many segregates.

The pods of A. aboriginorum are commonly glabrous. However, it is not uncommon for plants outside our range to bear strigose pods. Pubescent pods were noted by the writer in a single specimen from our region. The specimen was collected on the bank of the Heart River in Grant County, North Dakota by O A. Stevens and represents the only collection of the species from that state. In this material only the very young pods were strigose.

The type of this species has not been seen by the writer, but a specimen collected by Dr. Richardson on the Franklin Journey (MO) has been examined. It is labeled Phaca aboriginorum and agrees closely to the specimen figured by Hooker (1830). Hooker indicates that he had seen material which had been collected by Dr. Richardson. Since our material agrees closely with the Richardson specimen and with the Hooker figure and description there appears to be little doubt as to the typification of this species.

Polunin (1959) has recently treated A. aboriginorum as a synonym under A. australis (L.) Lam. The present author has examined a number of collections of A. australis from Europe and indeed that species does appear to belong to the same complex as A. aboriginorum. However, until it is possible to examine critically the members of this complex throughout its range it is best to retain our material under the name of A. aboriginorum.

The spelling of the specific epithet was aboriginorum in the original description, but Sprengel (1827), Torrey and Gray (1838), Gray (1864), and Rydberg (1900) have used the spelling aboriginum. The original spelling is retained in this paper because the International Code (Lanjouw, 1956, art. 73) states that the original spelling is to be retained unless it is a typographic error or an orthographic variant. Neither of these exceptions appear to fit this situation.

The species extends from Quebec to Alaska then southward to Nevada and New Mexico. The plants occur in meadows, stream banks, and wooded regions. In our region the flowering period extends from late May through June.

Ledingham (1957) has reported the somatic chromosome number of A. aboriginorum as 16.

*Astragalus agrestis Dougl. (Map 1. Plate 1, Figs. C, D)

Astragalus agrestis Dougl. ex G. Don, Gen. Syst. 2:258. 1832.
Astragalus hypoglottis sensu authors, non L. 1771.
Astragalus hypoglottis var. polyspermus T. and G., Fl. N. Am. 1:328. 1838.
Astragalus dasyglottis Nutt. ex T. and G., Fl. N. Am. 1:329. 1838. pro syn.
Astragalus goniatus Nutt. ex T. and G., Fl. N. Am. 1:330. 1838.
Phaca hypoglottis sensu MacMill. Metasp. Minn. Valley 324. 1892. pro syn.

*Astragalus virgultulus Sheld. Minn. Bot. Stud. 1:165. 1894.
Astragalus agrestis var. polyspermus (T. and G.) M.E. Jones Contr. West. Bot. 10:65. 1902.
Phaca agrestis (Dougl.) Piper Contr. U.S. Nat. Herb. 11:372. 1906.

Stems 9-43 cm long, few to several from a rhizome, decumbent, strigose throughout with simple hairs. Stipules 4-11 mm in length, connate-clasping below, the free ends lanceolate to triangular, glabrous or strigose on the dorsal (outer) surface, ciliate, herbaceous. Leaves 4-7 cm; leaflets 13-19, 6-15 mm long, 2-4 mm wide, narrowly elliptic, obtuse, strigulose above and below with simple hairs. Peduncles 4-19 cm long, strigose. Bracts linear-lanceolate, exceeding half the length of the calyx tube, villous with black and white hairs. Racemes 1-4 cm long, subcapitate, few- to several-flowered. Flowers 17-24 mm long, purple or occasionally ochroleucous, erect. Calyx cylindric, villous with dark and light simple hairs; tube 6-7 mm; teeth 2.8-5.5 mm, half as long as the tube, linear, usually black-villous. Pods 8-10 mm long, woolly villous, erect, subsessile, rupturing the persistent calyx, 2-celled by intrusion of the dorsal suture; the lower (dorsal) suture sulcate.

The stature of this species varies from one location to another. Plants from better sites may be four decimeters in height and those from less favorable situations may not exceed one decimeter. When the plants grow where competition is keen they frequently produce only a single stem, but in open sites they branch profusely and form dense clumps of vegetation. The prevailing flower color is pink-purple, but occasional specimens bear white flowers. A. virgultulus Sheldon was based on a caespitose form with white flowers.

A. agrestis is frequently mistaken for the related A. striatus from which it can be distinguished by its rhizomatous habit, long villous pods, and basifixed pubescence. A. agrestis has also been confused with A. plattensis which occurs in a similar habitat and has a rhizomatous habit. A. plattensis is usually more caespitose, has decumbent or ascending stems, fewer flowers, and more lax racemes. The mature pods of A. plattensis are much larger, ovoid-acuminate, and merely strigose.

A. agrestis appears to be a part of a complex with Eurasian as well as American representation. The majority of the early American workers considered our material to fall within the specific limits of A. hypoglottis (a European member of this complex). Jones (1895) was the first to take a firm position that A. agrestis was an entity distinct from A. hypoglottis. In 1898 he pointed out that A. agrestis differed from the European plants by its shaggy calyx, long calyx teeth, long bracts, and rough or puberulent vesture of the leaves. The treatment of A. agrestis in Jones' revision of the North American species of Astragalus (1923) includes a detailed comparison of the two species. The present author has also had some opportunity to study European material and concurs with Jones' interpretation.

However, R.C. Barneby (Wappingers Falls, N.Y.; 1959) in a personal communication now believes that A. agrestis is indistinguishable from the Siberian and central Asian A. dasyglottis Fisch. (possibly the source of the synonym A. dasyglottis Nutt.). The writer has not looked into the Asiatic end of this problem and is therefore unable to evaluate Barneby's

interpretation. No doubt the total Hypoglottides complex to which A. agrestis belongs should be studied as a unit; only then will it be possible to equate the constituent taxa in a consistent fashion. For the present, it seems desirable to maintain A. agrestis as definitive for the American representative.

Beyond our area the species extends northward to Alaska and south to Washington, Utah, and New Mexico. The plants occur in low, moist meadows, along stream courses and drainages, and less commonly in upland better drained sites and in woods. It is a common component of moist prairies of the northern great plains. The blooming period extends from May to early July.

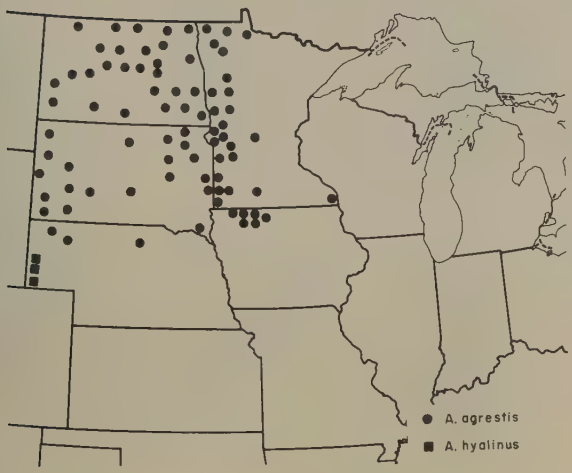
The somatic chromosome number of A. agrestis was reported as 16 by Ledingham (1957, under the name A. goniatus).

*Astragalus alpinus L. (Map 7. Plate II, Figs. A,B)

Astragalus alpinus L. Sp. Pl. 760. 1753.
Phaca astragalina DC. Astrag. 64. 1802.
Colutea astragalina (DC.) Poir. ex Lam., Encyc. Suppl. 1:561. 1810.
Phaca andina Nutt. Ex T. and G., Fl. N. Am. 1:345. 1838. pro syn.
Tragacantha alpina (L.) Kuntze Rev. Gen. 942. 1891.
Astragalus astragalinus (DC.) Sheld. Minn. Bot. Stud. 1:65. 1894.
Astragalus giganteus sensu Sheld. Minn. Bot. Stud. 1:65. 1894.
non A. giganteus S. Wats. 1882.
Tium alpinum (L.) Rydb. Bull. Torrey Club 32:659. 1905.
Phaca alpina (L.) Piper Contr. U.S. Natl. Herb. 11:371. 1906.
non P. alpina L. 1753.
Astragalus andinus (Nutt.) M.E. Jones Rev. Astrag. 137. 1923.
Atelophragma alpinum (L.) Rydb. Bull. Torrey Club 55:130. 1928.

Stems 9-44 cm long, few to several from a creeping rhizome, decumbent, strigulose throughout. Stipules 4-8 mm long, the lower ones connate-clasping, the upper ones nearly free, ovate to triangular, herbaceous, strigulose to glabrous on the dorsal surface. Leaves 6-15 cm long; leaflets 19-25, 7-20 mm long, 3-9 mm wide, ovate to elliptic or oblong, the apex retuse or rounded, strigulose above and below with simple pubescence. Peduncles 2-17 cm, strigulose. Bracts oblong, obtuse, longer than the pedicels, black-villous on the dorsal surface. Racemes 1-8 (13) cm, subcapitate, the flowers at first erect, later spreading and finally reflexed in age, several-flowered, elongating somewhat at maturity. Flowers 7-12 mm, light to dark purple, fading to yellow on drying. Calyx campanulate, strigulose with black hairs; tube 2.0-3.3 mm long; teeth 0.9-2.2 mm in length, narrowly triangular. Pods 12-21 mm, pendulous, strigose with black hairs, oblong-lanceolate, straight or slightly curved; the lower (dorsal) suture sulcate; stipe 2-4 mm long.

This species occurs in two widely separated regions in the north-central states: the South Dakota Black Hills and northern Wisconsin. The Black Hills representatives differ from their eastern congeners mainly in flower color, possessing pale whitish-purple petals except for



Map 1. Range of Astragalus agrestis and A. hyalinus.

Map 2. Range of Astragalus bisulcatus.

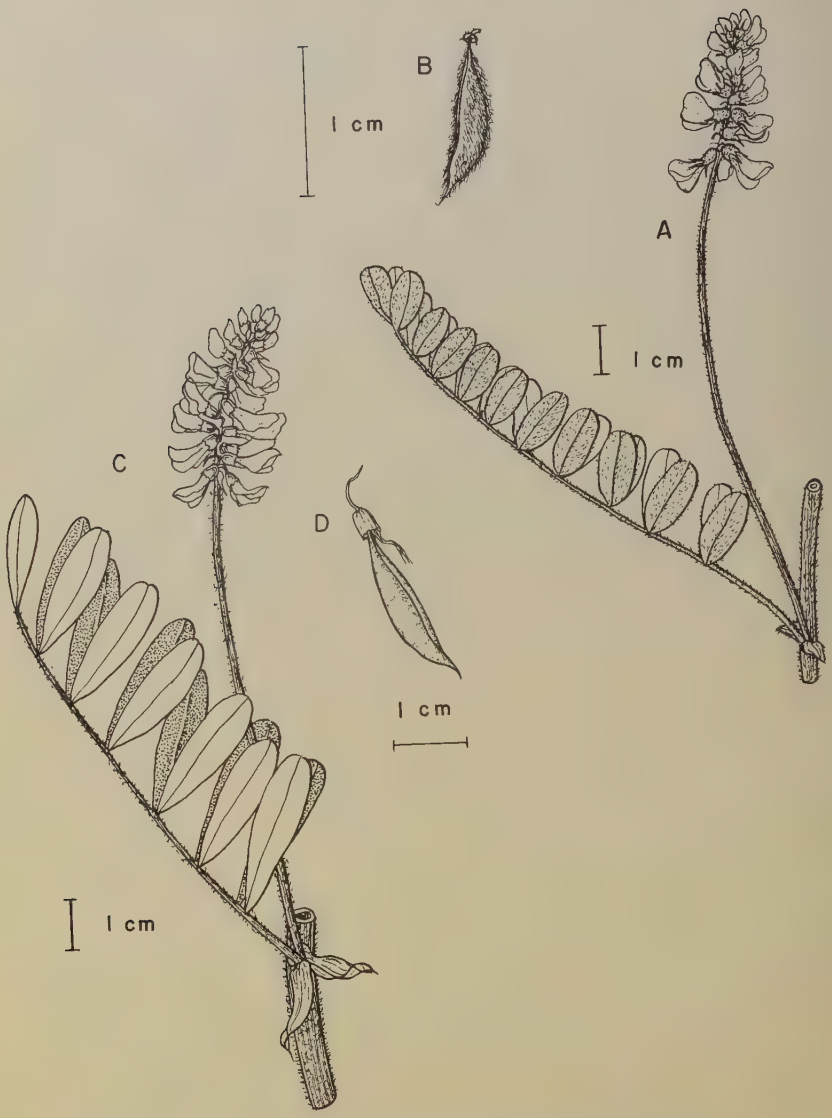


Plate II. Astragalus alpinus, A. Section of stem with leaf and inflorescence. B. Fruit. Astragalus americanus, C. Section of stem with leaf and inflorescence. D. Fruit.

the tip of the keel which is dark purple. The Wisconsin plants on the other hand bear brightly colored pink-purple flowers.

This species is widely distributed through the boreal, mountain, and subarctic regions of America, Europe, and Asia. In North America it occurs from Labrador to Alaska and southward to Vermont and Colorado. In our area the plants grow as a part of the ground layer in coniferous forests. The blooming period extends from June to late July.

*Astragalus americanus (Hook.) M.E. Jones (Map 4. Plate II, Figs. C, D)

Astragalus americanus (Hook.) M.E. Jones Contr. West. Bot. 8:8. 1898.
*Phaca frigida var. americana Hook. Fl. Bor. Am. 1:140. 1830.
Astragalus frigidus sensu Gray Proc. Am. Acad. 6:219. 1864. pro parte. non Phaca frigida L. 1759.
Astragalus frigidus var. americanus (Hook.) S. Wats. Bibl. Index 1:193. 1878.
Astragalus alpinus (L.) Sheld. var. americanus (Hook.) Sheld. Minn. Bot. Stud. 1:133. 1894.
Phaca americana (Hook.) Rydb. ex Britt. and Brown, Ill. Fl. 2:304. 1897.

Stems 30-75 cm long, few to several from a woody caudex, ascending to erect, sparsely villous with simple hairs. Stipules 11-22 mm long, ovate to lanceolate, free, the lower ones reflexed, turning brown with age, glabrous to sparsely villous with simple hairs. Leaves 9-16 cm long; leaflets 9-15, 15-58 mm long, 5-18 mm wide, oblong to lanceolate, obtuse, sparsely villous below, glabrous above. Peduncles 5-16 cm long. Racemes 2-9 cm long, several-flowered. Bracts oblong to elliptic, obtuse, nearly equalling the calyx. Flowers 12-13 mm, whitish, the keel with a purple tip. Calyx campanulate, oblique; tube 4-5 mm, glabrous or nearly so; teeth 0.2-0.7 mm, villous with black hairs (or some with a fringe of white hairs). Pods 23-32 mm long, ovoid-inflated, 1-celled, reflexed, glabrous (in ours); stipe 6-9 mm long, exceeding the calyx.

The pods from specimens collected in the Black Hills are glabrous, but there is a tendency for plants from widely scattered sites outside our range to have strigose pods. In this feature A. americanus approaches A. umbellatus of northern latitudes. However, the more robust nature, long peduncles, and small flowers distinguish A. americanus from that species.

Richardson (Franklin's Journey, 1823) listed this species as Phaca frigida Willd. Hooker (1830) followed suit but recognized three varieties, europea, americana, and littoralis, distinguished on pod and calyx characters. Rydberg (1929b) has recognized the varieties americanus and littoralis as distinct species. Jones (1923) held that A. americanus was distinct from the European A. frigidus. The present author concurs with the treatment of Jones.

Beyond our region the species extends from Quebec to the Yukon Territory and Alaska, south to British Columbia and Wyoming. The plants grow in wooded regions along streams or drainages. In the Black Hills the plants flower early in July. August specimens are in fruit.

Astragalus barrii Barneby (Map 7)

Astragalus barrii Barneby Am. Midl. Nat. 55:506. 1956.

Plants mat-forming; stems short, several to many from a broadly spreading caudex. Stipules 4-8 mm, glabrous dorsally, ciliate. Leaves 1-4 cm long; leaflets 3, 3-12 mm long, 1-3 mm wide, narrowly oblanceolate to elliptic, silvery-strigose with malpighian hairs. Peduncles 7-16 mm long. Bracts narrowly lanceolate, hyaline, glabrous dorsally, ciliate, longer than the pedicels. Racemes 1- to 3-flowered. Flowers 9-13 mm long; teeth 1.5-2.2 mm long, linear lanceolate. Pods 4-7 mm long, lance-ellipsoid, strigose, 1-celled, sessile.

A. barrii is possibly more closely related to A. sericoleucus than to any other species of Astragalus present in the north-central states. Both A. barrii and A. sericoleucus belong to that series of the Triphylli in which the purplish flowers are borne on pedunculate racemes. A. barrii is distinguished from A. sericoleucus largely on the basis of its glabrous stipules and larger flowers.

The writer has followed Barneby in maintaining A. barrii as a distinct species. However, when further information is available on this taxon it may possibly be relegated to the position of a variety.

Barneby (1956) reports the species as occurring in Fall River and Shannon Counties in South Dakota and from Wyoming and Montana. The plants grow in open places on calcareous soils at the tops of bluffs and along ravines. The blooming period of A. barrii is from late April through May.

Astragalus bisulcatus (Hook.) A. Gray (Map 2. Plate III, Figs. A-C)

Astragalus bisulcatus (Hook.) A. Gray U.S. War Dept. Pac. R.R. Rep. 12:38-1859.
*Phaca bisulcata Hook. Fl. Bor. Am. 1:145. 1834.
Tragacantha bisulcata (Hook.) Kuntze Rev. Gen. 943. 1891.
Astragalus bisulcatus forma hedysariformis Gand. Bull. Soc. Bot. Fr. 48: xiv. 1901.
Astragalus bisulcatus forma decalvans Gand. Bull. Soc. Bot. Fr. 48: xv. 1901.
Astragalus haydenianus forma leiocarpa Gand. Bull. Soc. Bot. Fr. 48: xv. 1901.
Diholcos bisulcatus (Hook.) Rydb. Bull. Torrey Club 32:664. 1905.
Diholcos decalvans (Gand.) Rydb. Bull. Torrey Club 32:664. 1905.

Stems 15-70 cm, several to many from a branching caudex, ascending to erect, minutely strigose throughout with simple hairs. Stipules 6-10 mm, connate-clasping below, the upper ones nearly free, triangular-lanceolate, glabrous to strigose on the dorsal surface. Leaves 6-10 cm long; leaflets 17-29, 8-27 mm in length, 2-10 mm in width, lanceolate to elliptic or oblong, distant or opposite, glabrous above, strigose below with simple pubescence. Peduncles 5-13 cm, minutely strigose. Bracts narrowly lanceolate, longer than the pedicels, sparsely strigose, ciliate.

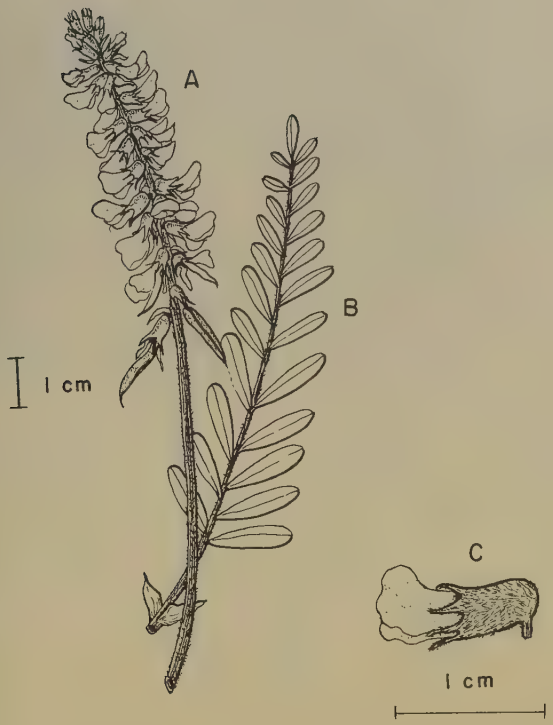


Plate III. Astragalus bisulcatus, A. Inflorescence with flowers and fruits. B. Leaf. C. Flower.

Racemes 4-19 cm long, many-flowered, at first very dense, later becoming lax as the rachis elongates. Flowers 10-15 mm long, some shade of pink or pink-purple (occasionally whitish), spreading. Calyx short-cylindric, very gibbous at the base (the rear of the calyx extending beyond the attachment of the pedicel); tube 3.5-5.5 mm; teeth 1.7-4.5 mm, narrowly linear. Pods 18-22 mm, linear-oblong, two furrows running the length of the ventral (upper) surface, reflexed, strigose, occasionally glabrous); stipe 4-6 mm long.

A. bisulcatus is frequently confused with (and perhaps related to) A. racemosus which occupies a similar habitat. A. racemosus is readily distinguished by its whitish flowers, long-stipitate and triquetrous pods, and only slightly gibbous calyces.

This species was described by Hooker from specimens collected by Drummond on the plains of the Saskatchewan. The descriptive epithet bisulcata has accompanied the taxon through transfers to several different genera. The only segregate to be elevated to specific rank was Gandoger's forma decalvans. Corolla color and pod pubescence (differential characters on which decalvans was based) do not correlate and there appears to be no basis for the recognition of the taxon decalvans in any category (a view also held by Porter, 1939).

A. bisulcatus extends northward into Saskatchewan and Alberta; southward through the mountains to New Mexico. It has been demonstrated (Trelease and Beath, 1949) that A. bisulcatus is a primary selenium indicator. The habitat of this species is restricted to seleniferous soils. Where seleniferous formations are exposed, as in the case of the Niobrara formation of western North and South Dakota, either A. bisulcatus or other selenophytes, such as A. racemosus, or A. pectinatus, are present. In only a few instances has the writer observed A. bisulcatus, A. racemosus, and A. pectinatus growing in the same vicinity. Evidently, controls in addition to selenium are present which limit the distribution of these plants since the ranges of the three species do not coincide.

This very attractive pink-purple flowered plant blooms from late May to mid-July in the north-central states. The flowering period is prolonged by the production of additional inflorescences as the season advances.

Both Vilkomerson (1943) and Ledingham (1957) have reported the somatic chromosome number of A. bisulcatus as 24.

Astragalus canadensis L. (Map 3. Plate IV, Figs. A-C)

* Astragalus canadensis L. Sp. Pl. 757. 1753.
Astragalus carolinianus L. Sp. Pl. 757. 1753.
Astragalus mortoni Nutt. Jour. Acad. Phila. 7:19. 1834.
Astragalus spicatus Nutt. ex T. and G., Fl. N. Am. 1:336. 1838. non A. spicatus Pall. 1773.
Astragalus canadensis var. mortoni S. Wats. Bot. King's Expl. 5:68. 1871.
Tragacantha canadensis (L.) Kuntze Rev. Gen. 943. 1891.
Phaca canadensis (L.) MacMill. Metasp. Minn. Valley 325. 1892.

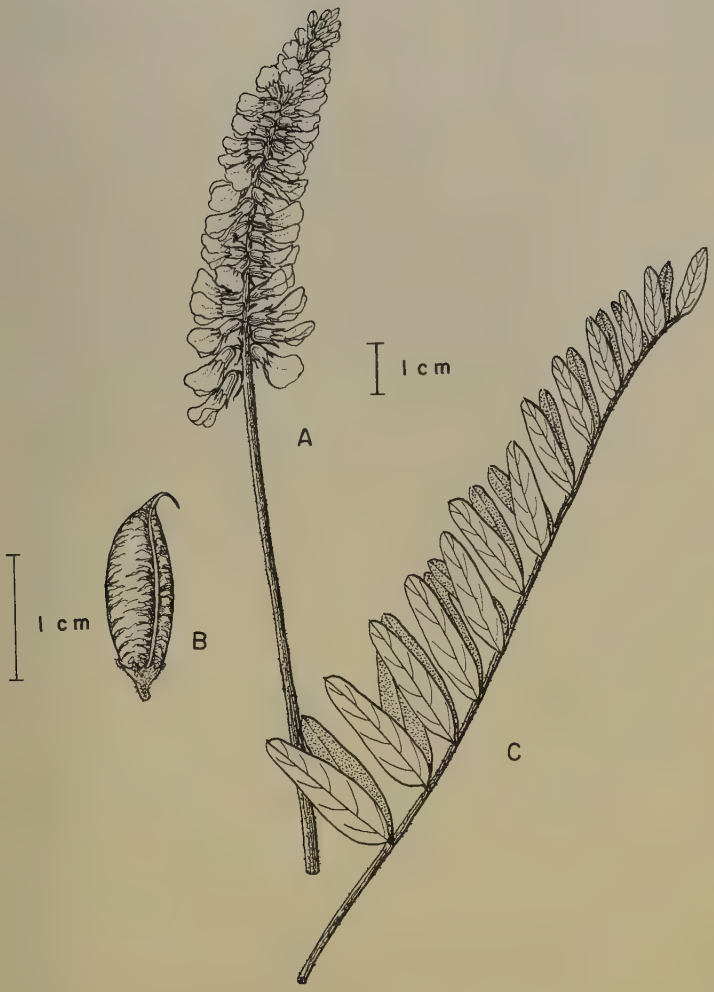


Plate IV. Astragalus canadensis, A. Inflorescence. B. Fruit. C. Leaf.

Astragalus canadensis var. carolinianus (L.) M.E. Jones Proc. Cal. Acad. II. 5:647. 1895.
Astragalus mortoni forma brevidens Gand. Bull. Soc. Bot. Fr. 48: xvi. 1901.
Astragalus mortoni forma rydbergii Gand. Bull. Soc. Bot. Fr. 48: xvi. 1901.
Astragalus canadensis forma monticola Gand. Bull. Soc. Bot. Fr. 48: xv. 1901.
Astragalus pachystachys Rydb. N. Am. Fl. 24:448. 1929.
Astragalus torreyi Rydb. N. Am. Fl. 24:448. 1929.
*Astragalus canadensis var. longilobis Fassett Rhodora 38:94. 1936.
Astragalus canadensis var. brevidens (Gand.) Barneby Leafl. West. Bot. 4:238. 1946.

Stems 25-130 cm, few to several from a branching woody caudex, ascending to erect, glabrous to minutely strigose throughout with simple pubescence. Stipules 5-12 mm long, connate-clasping, narrowly triangular, strigose on the dorsal surface. Leaves 10-31 cm; leaflets 15-35, 19-52 mm long, 6-16 mm wide, glabrous to sparsely strigose above, strigose below with at least some malpighian hairs; lanceolate to oblong, obtuse. Peduncles 4-12 cm long, strigose. Bracts narrowly lanceolate, longer than the pedicels, strigose on the dorsal surface. Racemes (3) 6-17 (19) cm long, many-flowered, little elongating in fruit. Flowers 12-15 mm long, ochroleucous, at first erect, later spreading or reflexed. Calyx cylindric, strigose with malpighian hairs; tube 5-8 mm; teeth 1.5-5.0 mm, narrowly linear to triangular. Pods 11-15 mm long, sessile, lance-ovoid to oblong, 2-celled, tardily dehiscent, erect, glabrous (rarely pubescent); both sutures prominent.

This species varies greatly in stature. The plants normally attain a height of between 0.5 meter and 1 meter, but occasional specimens may be less than 0.3 meter or over 1 meter in height.

The vesture of the leaves and stem is various. The leaflets commonly are strigose below and glabrous above; however, in extreme cases both surfaces are densely strigose as for example: Sheldon 1587, Aug. 1891, Lake Benton, Minn. Between these extremes are a series of intermediates which exhibit many degrees of pubescence.

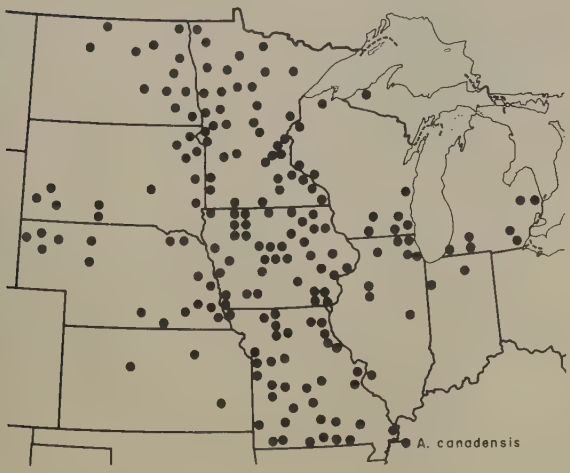
The length of the calyx teeth and bracts are likewise inconsistent. Fassett's A. canadensis var. longilobus represents a form with slender calyx teeth. A specimen collected in Winneshiek Co., Iowa (E.W.D. Holway, July 13, ISC) has calyx teeth to 5 mm in length. Whether such plants deserve the rank of a variety requires further study.

A specimen collected at Jefferson, Minnesota (H.L. Lyon, July 20, 1899, MIN) has exceptionally long bracts which much exceed the flowers in late bud. Typically the bracts exceed the length of the pedicel but not the calyx.

Although A. canadensis is not usually confused with other species of Astragalus (except perhaps A. cooperi) in the north-central states, it is frequently mistaken for Glycyrrhiza lepidota (and vice versa).

The glutinous nature of the calyx, smaller flowers, and acute leaflets should readily distinguish G. lepidota.

Confusion has existed concerning the various forms of this species in



Map 3. Range of Astragalus canadensis.

Map 4. Range of Astragalus americanus, A. ceramicus, and A. cooperi.

the western part of the United States. The names A. mortoni, A. spicatus, A. pachystachys, and A. torreyi have been variously applied to western phases of the total Astragalus canadensis complex.

This species is represented in one form or another from coast to coast. It grows in a variety of habitats and is commonly found in moist prairies, swampy areas, and in wooded regions.

The somatic chromosome number of A. canadensis has been reported as 16 by Tschechow (1935), Vilkomerson (1943), and Ledingham (1957).

Astragalus ceramicus Sheld. (Map 4. Plate V, Fig. A)

Astragalus ceramicus Sheld. Minn. Bot Stud. 1:19. 1894.
*Psoralea longifolia Pursh Fl. Am. Sept. 741. 1814.
Orobus longifolius (Pursh) Nutt. Gen. 2:95. 1818.
Physondra longifolia (Pursh) Raf. Atl. Jour. 145. 1832.
Phaca longifolia (Pursh) Nutt. ex T. and G., Fl. N. Am. 1:346. 1838.
*Phaca picta A. Gray Mem. Am. Acad. 4:37. 1849.
Astragalus filifolius A. Gray U.S. War Dept. Pac. R.R. Rep. 12:42. 1860. non A. filifolius Clos. ex Gray. 1846.
Astragalus pictus (A. Gray) A. Gray Proc. Am. Acad. 6:214. 1864. non A. pictus Boiss 1853. non A. pictus Stued. 1841.
Astragalus pictus var. foliolosus A. Gray Proc. Am. Acad. 6:215. 1864.
Astragalus pictus var. filifolius A. Gray Proc. Am. Acad. 6:215. 1864.
Tragacantha picta (A. Gray) Kuntze Rev. Gen. 947. 1891.
Astragalus pictus var. angustus M.E. Jones Zoe 4:37. 1893.
Astragalus ceramicus var. imperfectus Sheld. Minn. Bot. Stud. 1:19. 1894.
Astragalus ceramicus var. jonesii Sheld. Minn. Bot. Stud. 1:19. 1894.
Astragalus foliolosus (A. Gray) Sheld. Minn. Bot. Stud. 1:138. 1894. non A. foliolosus Bunge 1869.
Astragalus ceramicus var. longifolius (Pursh) Rydb. Bot. Surv. Neb. 3:31. 1894.
Astragalus angustus (M.E. Jones) M.E. Jones, Proc. Cal. Acad. II. 5:634. 1895.
Astragalus angustus var. pictus (A. Gray) M.E. Jones Proc. Cal. Acad. II. 5:635. 1895.
Astragalus angustus var. longifolius (Pursh) M.E. Jones Proc. Cal. Acad. II. 5:635. 1895.
Astragalus longifolius (Pursh) Rydb. Fl. Neb. 2:47. 1895. non A. longifolius Lam. 1783.
Astragalus filifolius (A. Gray) Smyth Trans. Kans. Acad. Sci. 15:61. 1898. non A. filifolius Clos. ex Gray. 1846.
Astragalus angustus var. imperfectus (Sheld.) M.E. Jones Contr. West. Bot. 10:62. 1902.
Astragalus angustus var. ceramicus (Sheld.) M.E. Jones Contr. West. Bot. 10:62. 1902.
*Astragalus pictus var. magnus M.E. Jones, Rev. Astrag. 109. 1923.

Plate V. Astragalus ceramicus, A. Plant with leaves, flowers and fruit. Astragalus cooperi, B. Inflorescence and leaf.

Astragalus longifolius (Pursh) F.C. Gates Trans. Kans. Acad. Sci. 42:137. 1939. non A. longifolius Lam. 1783.
Astragalus mitophyllus Kearney Leafl. West. Bot. 4:216. 1945.
Astragalus ceramicus var. filifolius (Gray) Herman Jour. Wash. Acad. Sci. 38:237. 1948.

Plants 14-41 cm long, stem arising from a creeping rhizome, prostrate to erect, strigose with malpighian hairs. Stipules 3-11 mm, connate-clasping at the base of the plant, with upper ones free, triangular subulate, stiff, persistent, strigose on the dorsal surface. Leaves 6-18 cm long; leaflets 1-11, the termimal leaflet commonly reduced to a long linear phyllode, more leaflets present on the lower leaves than on the upper. Peduncles 2-5 cm long, strigose. Bracts lanceolate-subulate, shorter than the pedicels. Racemes 2-5 (10) cm long. Flowers 7-12 mm in length, yellowish, the keel purple-tipped. Calyx campanulate, strigose; tube 2.2-4.0 mm; teeth 1.0-2.5 (3.5) mm, narrowly triangular. Pods 18-43 (51) mm long, thin-walled, inflated, glabrous, yellowish with purple mottling, or occasionally without mottling, 1-celled; stipe 2-5 mm long, usually included in the calyx.

This complex varies in the size of the pods and the nature of the leaves. The pods of the plants from our region are generally larger (25-50 mm long) than those from the west or southwest portions of the range (18-37 mm long). The pod size may or may not be correlated with leaflet number, but specimens from the west do tend to have a larger number of leaflets. The plants with many leaflets have been called var. foliolosus and those with a reduced number var. filifolius. There are many intergrades between these forms. The intraspecific variability of this complex awaits further study.

The long list of synonyms presented above actually involves only two specific types. These are the types of Psoralea longifolia and Phaca picta. As both of the specific epithets were preoccupied in Astragalus numerous name changes have resulted. A. ceramicus represents that segment of the complex which contains the type of Psoralea longifolia. If one wishes to recognize a second species the name A. angustus is available for the foliolose part of the complex. However, if one wishes to recognize only a single species having two varieties, the names would be A. ceramicus var. ceramicus for the type variety and A. ceramicus var. foliolosus for the foliolose portion of the species.

Outside our range the species extends westward to Montana and southward to Arizona and New Mexico. The rhizomatous habit allows the plants to adjust to changes in soil level. It is thus well suited to growth in sandy situations. The plants are common in the Sand Hills of western Nebraska where they occur in the sandy "blow outs." The blooming period extends from May to July.

Astragalus cooperi A. Gray (Map 4. Plate V, Fig. B)

Astragalus cooperi A. Gray Man. Bot. ed. 2. 98. 1856.
*Phaca neglecta T. and G. Fl. N. Am. 1:344. 1838.
Tragacantha neglecta (T. and G.) Kuntze Rev. Gen. 941. 1891.

Astragalus neglectus (T. and G.) Sheld. Minn. Bot. Stud. 1:59. 1894. non A. neglectus Freyn. 1893. non A. neglectus Fisch. ex Steud. 1841.
Phaca neglecta forma limonius Farwell Mich. Acad. Sci. Arts. Lett. 3:100. 1924.
Astragalus neglectus forma limonius (Farwell) Fern. Rhodora 39:318. 1937

Stems 50-75 cm long, few from a woody caudex, sparsely strigose with simple pubescence, ascending to erect. Stipules 3-5 mm, clasping, the free ends triangular, sparsely strigose, ciliate. Leaves 5-11 cm in length; leaflets 11-25, 10-29 mm long, 2-8 mm wide, oblong-elliptic or lanceolate, obtuse, truncate or retuse, strigose with simple hairs below, glabrous above. Peduncles 3-7 cm long, strigose. Bracts triangular, shorter than or equalling the pedicels. Racemes 1-5 cm long, several- to many-flowered. Flowers 10-12 mm long, whitish or yellowish. Calyx campanulate, strigose, fragile and soon crumbling; tube 3.5-5.0 mm long; teeth 1.5-2.3 mm long, triangular to narrowly triangular. Pods 12-35 mm long, glabrous, inflated, ovoid, sessile, 1-celled; both sutures sulcate.

A. cooperi has been mistaken for A. canadensis from which it can be separated by its short peduncles, campanulate (rarely subcylindric) calyces and inflated 1-celled pods. Also, the flowers are generally smaller.

Cooperi is the first available epithet, the earlier neglecta being preoccupied. As a substitute name A. cooperi must be based upon Phaca neglecta. The writer has examined three I.H. Lapham specimens (MO, US) which are possibly isotypes of the specimens cited by Torrey and Gray in the description of P. neglecta, and find that they closely agree with the original description and with the material considered herein as A. cooperi.

The species extends eastward to Pennsylvania and New York and northward into Ontario. The plants occur on sandy lake shores, river banks, and in open woods. The blooming period extends from late June to late July.

Astragalus crassicarpus Nutt. (Map 5. Plate VI, Figs. A,B)

Astragalus crassicarpus Nutt. Fraser Cat. 1. 1813.
Astragalus carnosus Pursh Fl. Am. Sept. 2:740. 1814.
Astragalus caryocarpus Ker. Bot. Reg. 2:176. 1816.
Astragalus succulentus Richards. ex Frankl., Jour. Bot. Append. 746. 1823.
Astragalus crassipes Fras. ex Steud., Nom. Bot. ed. 2. 1:160. 1841. pro syn.
Tragacantha caryocarpa (Ker.) Kuntze Rev. Gen. 943. 1891.
Phaca caryocarpa (Ker.) MacMil. Metasp. Minn. Valley 326. 1892. pro syn.
Astragalus prunifer Rydb. Mem. N.Y. Bot. Gard. 1:239. 1900.
Geoprumnon crassicarpum (Nutt.) Rydb. ex Small, Fl. SE. U.S. 616. 1903.

Geoprumnon succulentum (Richards.) Rydb. Bull. Torrey Club 32:658. 1905.
Astragalus succulentus var. paysoni Kelso Rhodora 39:151. 1937.
Astragalus crassicarpus var. paysoni (Kelso) Barneby Am. Midl. Nat. 55:497. 1956.

Stems 5-50 cm long, few to several from a woody caudex, prostrate to decumbent or ascending, strigose throughout with simple hairs. Stipules 4-12 mm long, fused to the petiole base, ovate to triangular, acuminate, the margins scarious, ciliate, glabrous on the dorsal surface. Leaves 4-11 cm long; leaflets 15-27, 8-20 mm in length, 2-8 mm in width, narrowly lanceolate to elliptic or linear-oblong, acute or obtuse, occasionally retuse (at least on the lower leaves), glabrous above, sparsely strigose to pilose below. Peduncles 2-8 cm long, strigose to pilose. Bracts lanceolate, glabrous on the dorsal surface, ciliate, longer than the pedicels. Racemes 2-4 cm, few- to several-flowered, at first dense, becoming lax in age. Flowers 14-20 mm, pinkish to purple, fading yellowish, the tip of the keel often remaining purple. Calyx cylindric, strigulose to villous with light to dark, simple hairs; tube 5.2-8.0 (9) mm; teeth 1.3-4.0 mm, triangular-subulate. Pods 16-27 mm long, 12-22 mm broad, ovoid-globose to quadrate, abruptly acuminate, sulcate along both sutures when fresh, fleshy prior to maturity and frequently reddish, becoming woody on drying, 2-celled, glabrous, sessile.

A. crassicarpus varies in several characters. The color of the flowers on the plants in the eastern part of the north-central states is at first a bright pink-purple, but this quickly fades to a yellowish or greenish color. Plants from central North Dakota westward have light yellowish wing-tips and banner, but the keel is pink-purple. Barneby (1956) has included the eastern plants in the type variety (possibly on the basis of the geographical area in which the type was collected), and treated the western plants as the variety paysoni.

The pods vary in shape from globose to ellipsoid or quadrate, but the apex in all cases is abruptly acuminate. The pods are frequently broader than long. In those which are exposed to the sunlight a red pigment is commonly formed, which accounts, at least in part, for the common name of "ground plum." In rare instances the yound pods may be minutely strigose.

The racemes are usually composed of somewhat compact subcapitate racemes. However, some plants from the Black Hills region and from North Dakota have very lax racemes. The plants bearing lax racemes also frequently possess light colored flowers and represent, at least in part, variety paysoni (Kelso) Barneby. The flowers of this variety may average slightly larger than those of the variety crassicarpus which ranges eastward.

The use of the above varietal names in A. crassicarpus appears to have some value as most of the flowering specimens can logically be placed in one category or another. However, fruiting specimens are often difficult to assign.

A. crassicarpus has been confused with A. trichocalyx. The two species appear to be closely related and have many similarities in

Plate VI. Astragalus crassicarpus, A. Section of stem with leaf and inflorescence. B. Fruit. Astragalus distortus, C. Section of stem with leaf and inflorescence. D. Fruit.

common. Indeed some authors (Barneby, 1956) have treated A. trichocalyx as a variety of A. carssicarpus. The present author has maintained A. trichocalyx as a distinct species on the basis of its geographic distribution, growth habit, flower color, and densely lanose calyx.

The utilization of the name A. crassicarpus has been subject to dispute. It was published in Fraser's Catalogue in 1813. The nomenclatural difficulties involve the facts: (1) that the description is too brief to delimit the species definitely; (2) that there is doubt as to the authorship of the Catalogue; (3) that it has been alleged that the Catalogue is not a valid publication source.

With respect to the first point, the description is indeed generalized, but there does not appear to be any other Astragalus "above the River Platte" which has the fruit "about the size and form of A. physodes, but thick and succulent."

Recently Shinners (1955, 1956), Cronquist et al. (1956), and Cronquist (1957) have discussed the authorship of the Catalogue and its validity. Nuttall did claim the authorship of a copy of the Catalogue which he sent to the Philadelphia Academy (Greene, 1890), and he acknowledged his responsibility (1818) for certain names in the Catalogue (cf. Amorpha canescens, Glycyrrhiza lepidota). As to the validity of that publication, the International Code does not hold that it is invalid. According to the International Code (art. 29, Lanjouw et al., 1956), publication on or after 1 Jan. 1953 of a new name in tradesmen's catalogues or in nonscientific newspapers, even if accompanied by a Latin diagnosis, does not constitute effective publication. Therefore, unless the Frazer Catalogue is declared invalid A. crassicarpus appears to be the earliest validly and effectively published name.

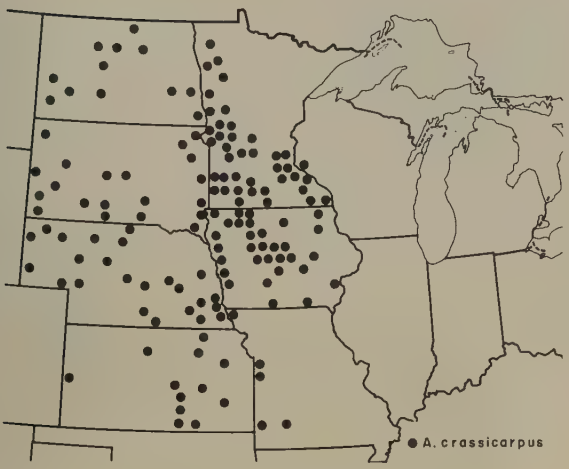
Beyond our area the species extends from Manitoba to Alberta in the north and southward along the plains to Texas and New Mexico. The plants occur in moist prairies, uplands, and on the short-grass prairie slopes of the Black Hills. In our region, it flowers from late March to early June.

Vilkomerson (1943) has reported the somatic chromosome number of A. crassicarpus as 22.

Astragalus distortus T. and G. (Map 7. Plate VI, Figs. C, D)

Astragalus distortus T. and G. Fl. N. Am. 1:333. 1838.
Tragacantha distorta (T. and G.) Kuntze Rev. Gen. 944. 1891.
Holcophacos distortus (T. and G.) Rydb. ex Small, Fl. SE. U.S. 618. 1903.

Stems 10-40 (60) cm long, decumbent to ascending, few to several from a branching caudex, sparsely strigose to glabrous. Stipules 3-8 mm long, free, triangular-subulate, glabrous on the dorsal surface, ciliate. Leaves 5-12 cm long; leaflets 17-27, 6-13 mm long, 2-7 mm wide, elliptic to oblanceolate, truncate to retuse, sparsely strigose below with simple hairs, glabrous above. Peduncles 5-15 cm, sparsely strigose. Racemes 1-6 cm, several-flowered, at first crowded, later becoming lax. Bracts lanceolate, shorter than or equalling the pedicels.



Map 5. Range of Astragalus crassicarpus.

Map 6. Range of Astragalus aboriginorum and A. drummondii.

Flowers 9-14 mm long, purple or ochroleucous with the keel purple-tipped. Calyx campanulate, strigose with white, simple hairs; tube 2.4-4.0 mm; teeth 1-2 mm long, triangular. Pods 15-20 mm long, sessile, 1-celled, curved, tapering at both ends, oblong, glabrous (occasionally sparsely strigose); dorsal suture sulcate, ventral suture conspicuous.

The flowers of A. distortus vary in color. They are commonly a bright pink-purple but yellowish flowers with purple-tipped keels frequently occur. White flowers are apparently rare but they do occur in this species as in most other Astragali.

Rydberg (1929) has included Phaca debilis Nutt. in the synonymy of A. distortus. However, the descriptions of the two taxa do not agree in several points and the type of P. debilis was collected beyond the range of A. distortus. Thus P. debilis and its synonyms have been omitted from the above list.

The range of the species extends southwestward to Texas and Louisiana and eastward to West Virginia. The plants occur on open sandy places along bluffs and streams, in open prairie glades along limestone outcrops, and in upland prairies. The plants flower from mid-April to early June.

Astragalus drummondii Dougl. (Map 6)

Astragalus drummondii Dougl. ex Hook., Fl. Bor. Am. 1:153. 1834.
Tragacantha drummondii (Dougl.) Kuntze Rev. Gen. 744. 1891.
Tium drummondii (Dougl.) Rydb. Bull. Torrey Club 32:659. 1905.

Stems 25-65 cm long, several from a woody caudex, shaggy villous with simple hairs, erect, coarse, ridged, stipules 5-12 mm long, free, ovate to triangular, sparsely villous with spreading hairs. Leaves 6-12 cm long; leaflets 21-33, 10-20 mm long, 4-7 mm broad, elliptic to oblanceolate, obtuse or truncate, villous with spreading, simple hairs below, glabrous above. Peduncles 6-15 cm, villous, at least some of the hairs black. Bracts ovate-lanceolate, acute, strigose, ciliate, shorter than or equalling the pedicels. Racemes 2-14 cm long, several- to many-flowered, at first much contracted, elongating in age. Flowers 16-21 mm, ochroleucous or whitish, the keel with a purple tip. Calyx cylindric, villous with dark and light simple hairs, persistent; tube 5.5-8.0 mm; teeth 2.4-4.0 mm, triangular-acuminate. Pods 24-40 mm long, linear-oblong, glabrous, reflexed; partially 2-celled by intrusion of the lower (dorsal) suture, the upper suture prominent; stipe 6-12 mm long.

A. drummondii has traditionally been placed with A. racemosus in the section Galegiformes (Tium Rydberg). However, there are some disconcerting differences between the two species. For example, the chromosome numbers differ; one is a selenium accumulator and the other is not, and the plants occupy distinct habitats. Pending a resolution of the relationships of A. drummondii, the author is maintaining it with the Galegiformes, but with some reservations.

The species was described by Hooker (1834) from materials collected by Douglas on the Eagle and Red Deer Hills of the Saskatchewan. The complete description and the fine figure of A. drummondii in the Flora

Boreali-Americana (loc. cit.) leave little doubt as to the typification of this species.

Beyond our region the species occurs northward to Saskatchewan and Alberta, southward through the mountains to Utah and New Mexico. The plants grow on foothills at middle elevations, but frequently extend down onto the high plains. The flowering period extends from late May to late June in our region.

A somatic chromosome number of 22 has been reported for A. drummondii by both Vilkomerson (1943) and Ledingham (1957).

Astragalus flexuosus (Hook.) G. Don (Map 17. Plate VII, Figs. A.B)

Astragalus flexuosus (Hook.) G. Don Gen. Syst. 2:256. 1832.
*Phaca elongata Hook. Fl. Bor. Am. 1:140. 1830. non A. elongatus Willd. 1803.
*Phaca flexuosa Hook. Fl. Bor. Am. 1:141. 1830.
Astragalus flexuosus Dougl. ex Hook., Fl. Bor. Am. 1:141. 1830. pro syn.
*Phaca fendleri A. Gray Mem. Am. Acad. II. 4:36. 1849.
Astragalus fendleri (A. Gray) A. Gray Pl. Wright. 2:44. 1853.
Tragacantha fendleri (A. Gray) Kuntze Rev. Gen. 944. 1891.
Tragacantha flexuosa (Hook.) Kuntze Rev. Gen. 945. 1891.
Astragalus gracilentus var. fallax (Wats.) M.E. Jones Contr. West. Bot. 8:14. 1898.
Astragalus flexuosus var. elongatus (Hook.) M.E. Jones Contr. West. Bot. 10:58. 1902.
Astragalus flexuosus var. fendleri (A.Gray) M.E. Jones Contr. West. Bot. 10:62. 1902.
Homalobus flexuosus (Hook.) Rydb. Bull. Torrey Club 32:666. 1905.
Homalobus fendleri (A. Gray) Rydb. Bull. Torrey Club 32:667. 1905.
*Pisophaca sierrae-blancae Rydb. N. Am. Fl. 24:323. 1929.
Pisophaca flexuosa (Hook.) Rydb. N. Am. Fl. 24:324. 1929.
*Pisophaca ratonensis Rydb. N. Am. Fl. 24:324. 1929.
Pisophaca elongata (Hook.) Rydb. N. Am. Fl. 24:325. 1929.
Astragalus flexuosus var. sierrae-blancae (Rydb.) Barneby Leafl. West. Bot. 4:54. 1944.

Stems 25-65 (70) cm long, several from a branching subterranean caudex, decumbent to ascending, flexuous, strigulose throughout with simple hairs. Stipules 3-8 mm long, connate-clasping, the free ends triangular-acuminate. Leaves 5-8 cm, petioles short; leaflets 15-25, 6-11 mm long, 2-4 mm wide, elliptic to oblong or linear-oblong, obtuse, truncate or cuspidate, glabrous above, strigulose with simple hairs below. Peduncles 5-15 cm long, strigulose. Bracts lanceolate, longer than the pedicels or equalling them, 1-2 mm long. Racemes 4-16 cm, several-flowered, elongating in fruit. Flowers 8-10 mm long, pinkish or purplish; the keel purple-tipped. Calyx campanulate, strigulose with white and dark simple hairs; tube 3.0-3.8 mm; teeth 0.5-1.3 mm, triangular. Pods 13-20 mm long, oblong, tapering at both ends, 1-celled, round in cross-section, spreading, dehiscent, strigose; both sutures prominent; stipe 1-2 mm long, included in the persistent calyx.

A. flexuosus has been mistaken for A. gracilis in vegetative condition. The larger stipules of A. flexuosus can be used to distinguish most doubtful specimens. Another species that is frequently confused with A. flexuosus is A. tenellus. From that species A. flexuosus may be distinguished by its dorsally compressed pods and pink-purple flowers (in ours). The stipules of A. tenellus commonly turn black on drying and this may be used as a feature in the separation of doubtful material.

There is some difficulty in designating a proper author citation for A. flexuosus. The combination A. flexuosus Douglas was originally published as a synonym of Phaca flexuosa Hooker (1830). In 1832 Don published the name Astragalus flexuosus, ascribing the name to Douglas. He did not list Hooker's P. flexuosa in the synonymy and indicated that the plant had been collected in North West America (Hooker cites P. flexuosa from "Red River and Assinaboin"). Until it is possible to examine these types it is perhaps best to treat Don's name as an inadvertent comb. nov. of Hooker's P. flexuosa.

The species occurs from Saskatchewan and Alberta southward to New Mexico and Arizona. The single collection from Nebraska is probably adventive. The habitat of A. flexuosus varies from dry gravelly soil along roadsides to grassy prairies and the slopes of mountains. It is commonly found at middle and low elevations in more open situations. In the north-central states the plants flower from late May to mid-July.

Ledingham (1957) states that the somatic chromosome number of A. flexuosus is 22.

Astragalus gilviflorus Sheld. (Map 11. Plate VIII, Fig. A)

Astragalus gilviflorus Sheld. Minn. Bot. Stud. 1:21. 1894.
Astragalus triphyllus Pursh Fl. Am. Sept. 740. 1814. non A. triphyllus Pallas 1800.
Phaca caespitosa Nutt. Gen. 2:98. 1818. non A. caespitosus Pallas 1800.
Phaca triphylla (Pursh) Eaton and Wright N. Am. Bot. 351. 1840.
Tragacantha triphylla (Pursh) Kuntze Rev. Gen. 947. 1891.
Orophaca caespitosa (Nutt.) Britt. ex Britt. and Brown. Ill. Fl. 2:306. 1897.

Plants pulvinately caespitose. Stems 1-4 cm long, several from a branching woody caudex, entirely covered by stipules and leaf bases. Stipules 10-18 mm long, glabrous, hyaline, ciliate, connate-clasping, ovate, the free ends occasionally produced into a bifid apex. Leaves 3-7 cm long, palmately trifoliolate (rarely 5-foliolate), silvery pilose with malpighian hairs; leaflets 7-20 mm long, 2-7 mm wide, spatulate to elliptic. Flowers borne in 1- to 4-flowered sessile, axillary clusters, 18-29 mm long, ochroleucous to whitish, the keel purple-tipped. Bracts stipule-like, clasping, ovate with a long acuminate apex, glabrous, hyaline, borne immediately below the base of the calyx. Calyx cylindric, villous; tube 10-14 mm long, teeth 3.0-4.0 mm long, triangular-subulate. Pods 7-9 mm long, acuminate-ovoid, with a short beak, villous, 1-celled, sessile.

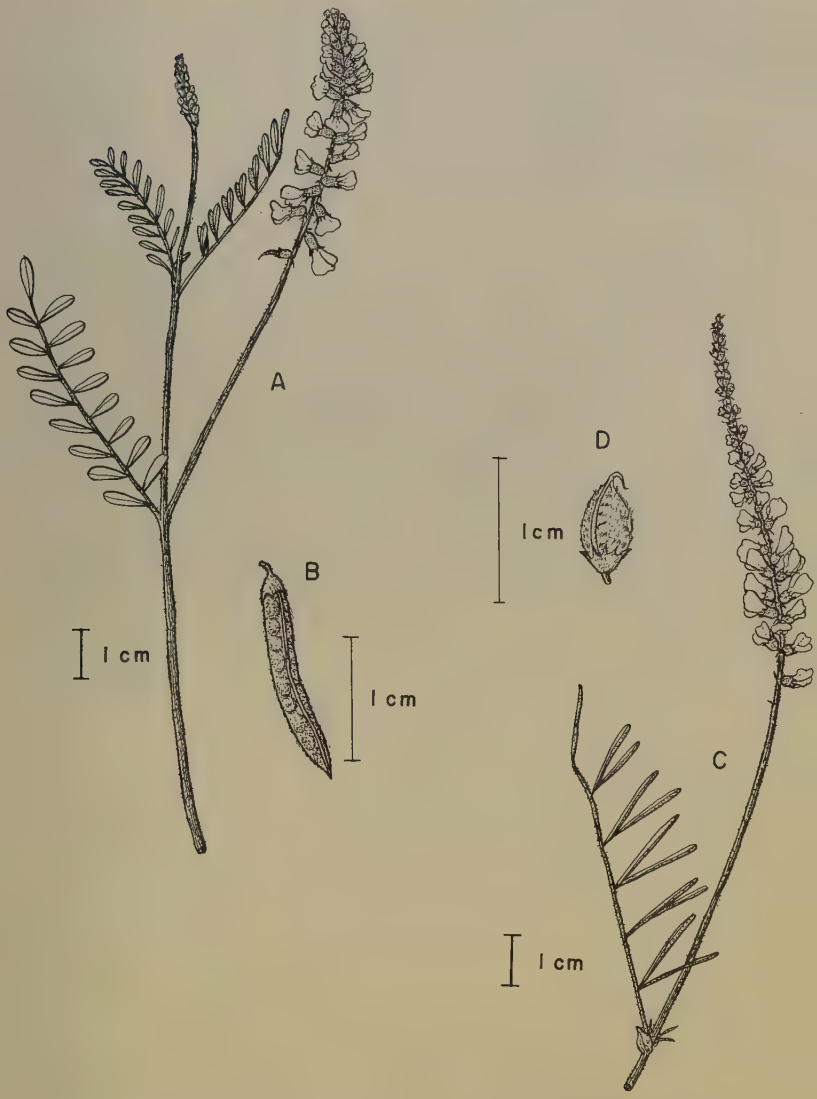


Plate VII. Astragalus flexuosus, A. Portion of plant with leaves and inflorescences. B. Fruit. Astragalus gracilis, C. Section of stem with leaf and inflorescence. D. Fruit.

This species varies considerably in the length of the leaves, size of the clump which is formed, and in the size of the flowers. All of these characters appear to be affected by the type of environment in which the plants grow. Those of open or barren areas where there is little competition are frequently more robust than plants from less favorable sites where competition is keen. The stage of development is also important as regards the length of the leaves and the size of the plant. The longest leaves most commonly occur on fruiting specimens. Young plants may be only 5-10 cm broad, but old specimens may commonly exceed 25 cm in breadth.

A. gilviflorus is possibly most closely related to A. hyalinus. Indeed, these two species form a distinct morphological series in the Triphylli. The inflorescences are sessile or subsessile, the flowers are yellowish or whitish, and the calyces are long cylindric in the members of this series. A. gilviflorus can be distinguished from A. hyalinus by its glabrous petals and larger flowers.

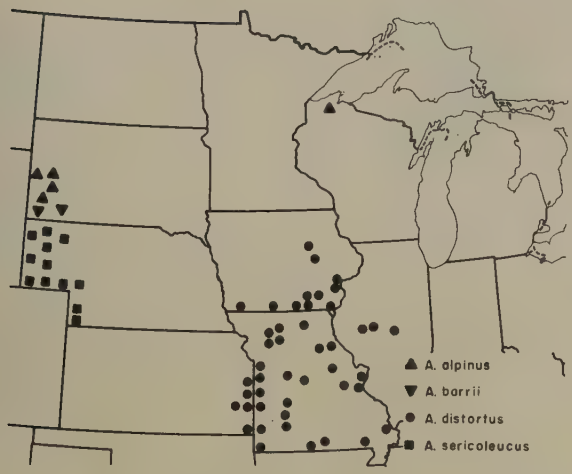
Because A. gilviflorus is a substitute name it must be based upon A. triphyllus Pursh. No type of A. triphyllus has been seen, but there seems to be little doubt that Pursh's characterization (1814, p. 740) could apply to any other species "in upper Louisiana." He described the plant as "A. acaulis, argenteus, foliis ternatis, foliolis sessilibus lanceolatis, scapo nullo, leguminibus sessilibus oblongis" and further that the leaves were "of a shining silver colour."

The species extends northward into Saskatchewan and Alberta, and westward into Montana and Wyoming. The plants occur along slopes, bluffs, and ravines in upland situations. The blooming period is from early May to mid-June.

The somatic chromosome number of A. gilviflorus is reported to be 22 (Ledingham, 1957).

Astragalus gracilis Nutt. (Map 8. Plate VII, Figs. C, D)

Astragalus gracilis Nutt. Gen. 2:100. 1818.
Dalea parviflora Pursh Fl. Am. Sept. 474. 1814. non A. parviflorus Lam. 1783.
Psoralea parviflora (Pursh) Poir. ex Lam., Encyc. Suppl. 4:590. 1816.
Astragalus gracilis var. β erectus Hook. London Jour. Bot. 6:210. 1847.
*Astragalus parvifolius Nutt. ex A. Gray Proc. Am. Acad. 6:202. 1864. pro syn.
*Astragalus microlobus A. Gray Proc. Am. Acad. 6:203. 1864.
Tragacantha parviflora (Pursh) Kuntze Rev. Gen. 941. 1891.
Tragacantha microloba (A. Gray) Kuntze Rev. Gen. 946. 1891.
Astragalus parviflorus (Pursh) MacMil. Metasp. Minn. Valley 325. 1892. non A. parviflorus Lam. 1783.
Phaca gracilis (Nutt.) MacMill. Metasp. Minn. Valley 325. 1892. pro syn.
Microphacos gracilis (Nutt.) Rydb. Bull. Torrey Club 32:663. 1905.
Microphacos microlobus (A. Gray) Rydb. Bull. Torrey Club 32:663. 1905.



Map 7. Range of Astragalus alpinus, A. barrii, A. distortus, and A. sericoleucus.

Map 8. Range of Astragalus gracilis.

Microphacos parviflorus (Pursh) Rydb. Bull. Torrey Club 40:51. 1913.
Astragalus parviflorus var. microlobus (A. Gray) M.E. Jones Rev. Astrag. 193. 1923.
Astragalus microphacos Cory Rhodora 38:495. 1935.
Astragalus gracilis var. parviflorus (Pursh) F.C. Gates Trans. Kans. Acad. Sci. 42:137. 1939.

Stems 15-100 cm long, few to several from a woody caudex or from short vertical rhizomes which lead from an underground caudex, strigose with simple hairs, prostrate to erect. Stipules 1-4 mm long, connate-clasping, the free ends triangular-subulate, strigose. Leaves 4-9 cm, short-petiolate; leaflets 7-17, 5-23 mm long, 1-4 mm wide, narrowly linear to linear-oblong, obtuse or retuse, strigose below, glabrous above, commonly folding on drying. Peduncles 3-13 cm long, strigose. Bracts narrowly lanceolate-subulate, shorter than the pedicels. Racemes 2-17 cm long, several- to many-flowered, elongating at maturity. Flowers 4-8 mm long, light purple. Calyx campanulate, strigose, tube 1.0-2.5 mm long, teeth 0.4-0.9 mm long, triangular. Pods 5-10 mm long, ovate, boat-shaped, 1-celled, strigulose, cross-ribbed, reflexed, sessile; the dorsal suture sulcate or occasionally merely flattened.

A. gracilis varies in the shape of the leaflets and in the stature or habit of growth. In one extreme the plants are tall and erect or ascending and commonly bear narrowly linear leaflets. At the other extreme the plants are short and prostrate to decumbent, and commonly bear oblong to linear-oblong leaflets. The low-growing plants also commonly possess shorter peduncles and racemes and fewer flowers. The flower and fruit size intergrade and there are a series of intermediates in both leaflet shape and plant stature. This complex of forms has been variously interpreted. Some authors have treated the group as two distinct species (Gray and Rydberg); others have believed it more realistic to consider it a single species consisting of two varieties (Jones and Gates). The present author agrees with the latter treatment.

A. gracilis appears to be closely related to A. flexuosus. The habit of the low-growing forms is similar to A. flexuosus. The stems arise from a series of short vertical rhizomes which are borne on subterranean caudices. A. flexuosus commonly exhibits a similar habit. The stems in both species are flexuous and both have dorsally compressed pods.

It is possible that the low-growing forms of A. gracilis have arisen as the result of introgressive hybridization between the tall A. gracilis and A. flexuosus.

Beyond our region this species extends from eastern Montana southward to New Mexico, northern Texas, and western Oklahoma. A. gracilis is common on dry bluffs, slopes, and in open grasslands. The flowering period is from mid-May to mid-July.

*Astragalus hyalinus M.E. Jones (Map 1)

Astragalus hyalinus M.E. Jones Proc. Cal. Acad. II. 5:648. 1895.
Phaca argophylla Nutt. T. and G., Fl. N. Am. 1:342. 1838. non A. argophyllus Nutt. 1838.
Orophaca argophylla (Nutt.) Rydb. ex Britt., Man. ed. 2. 1067. 1905.

Plants pulvinately caespitose. Stems 1-3 cm long, several from a branching caudex. Stipules 6-15 mm long, connate-clasping, ovate, hyaline, glabrous on the dorsal surface, bearing a tuft of long-villous hairs at the base; margin ciliate. Leaves 1-3 cm long, palmately trifoliolate (occasionally 5-foliolate), silvery pilose with malpighian hairs; leaflets 6-8 mm long, spatulate. Flowers borne sessile in the axils of the leaves, 1-3, 12-16 mm long, yellowish or whitish, strigose on the outside with malpighian hairs. Calyx cylindric, woolly villous; tube 7.0-7.5 mm long, teeth 2.5-3.0 mm long, narrowly triangular. Pods 7-10 mm long, 1-celled, pilose to villous with malpighian hairs, sessile.

The fruit of this species has not been seen by the writer, but Porter (Harrington, 1954) reports the pods as being 7-10 mm long.

Barneby has reported A. hyalinus from Fall River Co., South Dakota (personal communication). Beyond our area the species occurs through northeastern Colorado and southeastern Wyoming. The plant grows in open areas along bluffs and ravines where it is frequently associated with other members of the Triphylli. The blooming period of A. hyalinus occurs during July; later than other members of the complex.

*Astragalus lotiflorus Hook. (Map 9. Plate VIII, Figs. B, C)

Astragalus lotiflorus Hook. Fl. Bor. Am. 1:152. 1834.
Phaca cretacea Buckl. Proc. Acad. Phila. 1861:452. 1863. non A. cretaceus Pallas 1776.
*Astragalus lotiflorus var. pedunculosus A. Gray Proc. Am. Acad. 6:209. 1864.
*Astragalus lotiflorus var. brachypus A. Gray Proc. Am. Acad. 6:209. 1864.
Astragalus reverchoni A. Gray Proc. Am. Acad. 19:74. 1883.
Tragacantha lotiflora (Hook.) Kuntze Rev. Gen. 946. 1891.
Astragalus elatiocarpus Sheld. Minn. Bot. Stud. 1:20. 1894.
*Astragalus lotiflorus var. nebraskensis Bates Am. Nat. 29:670. 1895.
Astragalus ammolotus Greene Erythea 3:76. 1895.
Astragalus lotiflorus var. elatiocarpus (Sheld.) Rydb. Mem. N.Y. Bot. Gard. 1:244. 1900.
Astragalus lotiflorus var. reverchoni (A. Gray) M.E. Jones Contr. West. Bot. 10:61. 1902.
Phaca reverchoni (A. Gray) Rydb. ex Small. Fl. SE. U.S. 619. 1903.
Phaca elatiocarpa (Sheld.) Rydb. Bull. Torrey Club 32:665. 1905.
Astragalus nebraskensis (Bates) Bates Torreya 5:216. 1905.
*Astragalus batesii A. Nels. Bot. Gaz. 54:150. 1912.
Cytospora elatiocarpa (Sheld.) Lunell Am. Midl. Nat. 4:428. 1916.
Cytospora lotiflora (Hook.) Lunell Am. Midl. Nat. 4:428. 1916.

Batidophaca lotiflora (Hook.) Rydb. N. Am. Fl. 24:321. 1929.
Batidophaca cretacea (Buckl.) Rydb. N. Am. Fl. 24:322. 1929.
Batidophaca nebraskensis (Bates) Rydb. N. Am. Fl. 24:322. 1929.
Astragalus lotiflorus var. cretaceus (Buckl.) Gates Trans. Kans. Acad. Sci. 42:137. 1939.

Stems 3-17 cm long, caespitose, several from a branching caudex, strigose to villous with malpighian hairs. Stipules 4-9 mm long, connate-clasping, the free ends triangular-subulate, strigose. Leaves 6-14 cm long, petioles of moderate length; leaflets 9-19, 12-18 mm long, 4-6 mm wide, oblong to elliptic or oval, obtuse or occasionally acute, strigose to villous above and below with malpighian hairs. Inflorescences of two types; the early ones pedunculate (6-10 cm long), frequently not producing fruit; the later ones sessile or short-pedunculate (to 2 cm long), usually producing fruit. Flowers 6-10 mm, yellowish or rarely purplish, the late flowers cleistogamous. Calyx campanulate, strigose with malpighian hairs, splitting in fruit; tube 3.0-4.3 mm; teeth 2.5-4.5 mm, narrowly triangular. Pods of both flower types 19-33 mm, strigulose to villous (occasionally long-villous) with malpighian hairs, 1-celled, lance-ovoid, sessile, drying to a yellowish tan color; both sutures prominent, the ventral one acute, the dorsal one flattened, tardily dehiscent.

The varieties pedunculosus and brachypus of Gray were based upon variants of A. lotiflorus which bear pedunculate and sessile inflorescences respectively. However, both types are frequently produced by the same plant and the recognition of these forms in varietal status seems untenable. Sheldon (1894) elevated variety brachypus to specific rank (A. elatiocarpus) because of his mistaken idea that the sessile flowers were elevated by the elongation of the peduncle as the fruit matured.

The vesture ranges from appressed short-villous to long-villous. An extremely villous form, occurring from North Dakota to Kansas and Wyoming, was described by Bates as the variety nebraskensis. There are numerous intermediates between this variety and the more widespread less conspicuously pubescent form.

The color of the flowers, though usually yellowish, varies considerably. There are gradations from whitish to yellowish, light purple, and dark pink-purple. A pale violet-flowered form was described as A. batesii A. Nels.

The plants from the southern part of the great plains tend to have large numbers of flowers and long peduncles. This part of the complex represents what has been called A. reverchoni (Phaca cretacea). These plants also tend to have a greater proportion of fertile pedunculate flowers and fewer cleistogamous inflorescences than those farther north; whether they deserve varietal status is beyond the scope of this paper.

The species does not seem to be closely related to others in the north-central states although it is superficially similar to A. missouriensis. It can be distinguished from the latter species by its spreading pubescence and campanulate calyx with long teeth.

A. lotiflorus was described by Hooker (1834) from material collected by Drummond at Carlton House, Saskatchewan, and his excellent description and discussion of the species could hardly apply to any other.

Plate VIII. Astragalus gilviflorus, A. Plant with leaves and flowers. Astragalus lotiflorus, B. Plant with sessile fruits. C. Pedunculate inflorescences and leaf.

The names A. reverchoni and A. ammolotus require clarification. A. reverchoni is a substitute name which was proposed by Gray to replace Phaca cretacea as that name was preoccupied in Astragalus. The name A. ammolotus was proposed by Greene (1895) to replace A. elatiocarpus because "it was compounded of words taken from two languages."

A. lotiflorus extends northward through Saskatchewan and Alberta, and southward to Oklahoma and New Mexico. The plants occur on sandy bluffs, on gravelly beaches, and in dry prairies. The blooming period extends from late April through June.

*Astragalus missouriensis Nutt. (Map 10. Plate IX, Figs. A,B)

Astragalus missouriensis Nutt. Gen. 2:99. 1818.
Astragalus melanocarpus Nutt. Fraser Cat. 1. 1813. nom. nud.
Astragalus setosus Pursh ex Richards., Frankl. Jour. Bot. Append. 746. 1823. pro syn.
Astragalus missouriensis var. β Nutt. ex T. and G., Fl. N. Am. 1:331. 1838.
Tragacantha missouriensis (Nutt.) Kuntze Rev. Gen. 946. 1891.
*Astragalus missouriensis forma longipes Gand. Bull. Soc. Bot. Fr. 48: xv. 1901.
*Astragalus missouriensis forma microphylla Gand. Bull. Soc. Bot. Fr. 48: xv. 1901.
Astragalus missouriensis forma leucophaea Gand. Bull. Soc. Bot. Fr. 48: xvi. 1901.
Xylophacos missouriensis (Nutt.) Rydb. ex Small, Fl. SE. U.S. 620. 1903.

Plants caespitose. Stems 4-12 cm long, few to several from a branching caudex, decumbent to ascending, grayish-canescent, mostly covered by stipules and leaf bases. Stipules 4-10 mm, connate-clasping, ovate to lanceolate, strigose with malpighian hairs. Leaves 5-11 cm, silvery-canescent throughout due to appressed malpighian hairs; leaflets 13-17, 5-15 mm long, 3-7 mm wide, elliptic to obovate. Peduncles 2-12 cm, coarse, canescent. Bracts lanceolate, strigose on the dorsal surface, longer than the peduncles. Racemes 1-4 cm, subcapitate, few-flowered. Flowers 12-20 mm, pink-purple (rarely white). Calyx cylindric, strigose with black and white malpighian hairs, appearing gray; tube 6.2-8.5 mm, teeth 2.0-4.5 mm, triangular-subulate. Pods 15-28 mm, lance-ovoid, sessile, 1-celled, drying dark, strigose with malpighian hairs, dehiscent; both sutures prominent.

The specific epithet melanocarpus (listed above) has long been treated as a synonym of A. missouriensis. However, since the name was published without a description (nomen nudum), there has been proper doubt as to its disposition. The writer has examined a specimen (OXF) of A. missouriensis which was collected at "Red River" Canada by Douglas. It is labeled A. melanocarpus. This indirect evidence adds weight to the traditional application of A. melanocarpus in the synonymy of A. missouriensis.

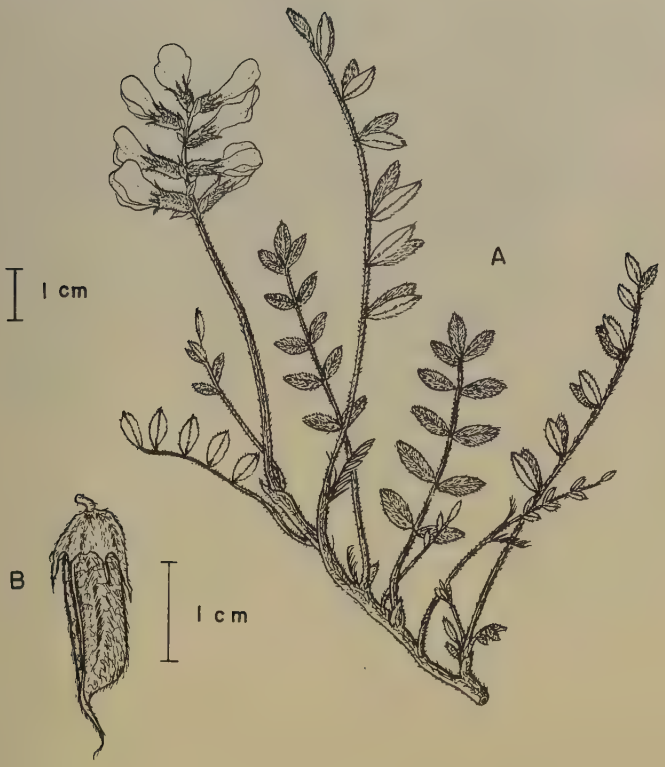


Plate IX. Astragalus missouriensis, A. Part of plant with leaves and inflorescence. B. Fruit.

Outside our region the species ranges northward into Saskatchewan and Alberta then southward to Utah and New Mexico. It typically occurs in short-grass prairies, uplands, bluffs, and in more open regions. Flowering extends from late April in the southern part of the range to early July in North Dakota.

The somatic chromosome number of A. missouriensis is reported to be 22 (Ledingham, 1957).

Astragalus mollissimus Torr. (Map 11. Plate X, Figs. A,B)

Astragalus mollissimus Torr. Ann. Lyc. N.Y. 2:178. 1827.
Phaca villosa James Trans. Am. Phil. Soc. II. 2:186. 1825. Non A. villosus Gueld. 1791.
Tragacantha mollissima (Torr.) Kuntze Rev. Gen. 946. 1891.
Astragalus simulans Cockll. Torreya 2:154. 1902.

Plants caespitose, 10-30 cm tall. Stems several to many from a caudex, decumbent to ascending, villous throughout with simple hairs. Stipules 8-18 mm long, connate-clasping, ovate to lanceolate, acuminate, densely villous. Leaves 10-24 cm, densely villous with fine spreading hairs; leaflets 21-35, 8-25 mm long, 4-12 mm wide, ovate to elliptic or obovate. Peduncles 9-18 cm, very coarse, villous. Bracts lanceolate, villous, longer than the pedicels. Racemes 2-11 mm, several- to many-flowered, little elongating in fruit. Flowers 15-19 mm, greenish-purple. Calyx cylindric, white-villous; tube 7.0-9.0 mm, teeth 2.5-5.0 mm, triangular-acuminate. Pods 13-20 mm, curved, oblong, glabrous, sessile, 2-celled by the intrusion of the dorsal suture; both sutures sulcate.

The species extends southwestward from our region through eastern Wyoming and Colorado to New Mexico and Texas. The plants are common in short-grass prairies where they grow in the flats and on rolling hills or bluffs. In over-grazed pastures they may be the most conspicuous vegetation.

A. mollissimus has long been regarded as a livestock poisoner (Ritter, 1917). The animals which eat it develop a craving for the plant and frequently die from it. It is not a selenophyte, but the poisoning produced may be mistaken for that of selenium (Trelease and Beath, 1949).

The plants flower from May to early July.

Astragalus pectinatus (Hook.) G. Don (Map 12. Plate XI, Figs. A,B)

Astragalus pectinatus (Hook.) G. Don Gen. Syst. 2:257. 1832.
Phaca pectinata Hook. Fl. Bor. Am. 1:141. Tab. LIV. 1830.
Astragalus pectinatus Dougl. ex Hook., Fl. Bor. Am. 1:142. 1830. pro syn. Phaca pectinata Hook.
Tragacantha pectinata (Hook.) Kuntze Rev. Gen. 947. 1891.
Astragalus pectinatus var. platyphyllus M.E. Jones Contr. West. Bot. 10:87. 1902.
Ctenophyllum pectinatus (Hook.) Rydb. Bull. Torrey Club 32:663. 1905.
Cnemidophacos pectinatus (Hook.) Rydb. N. Am. Fl. 24:288. 1929.

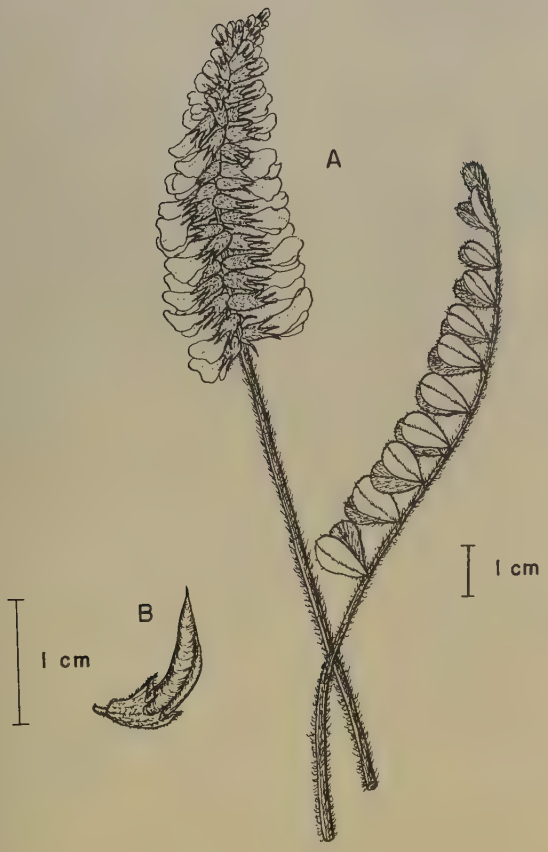
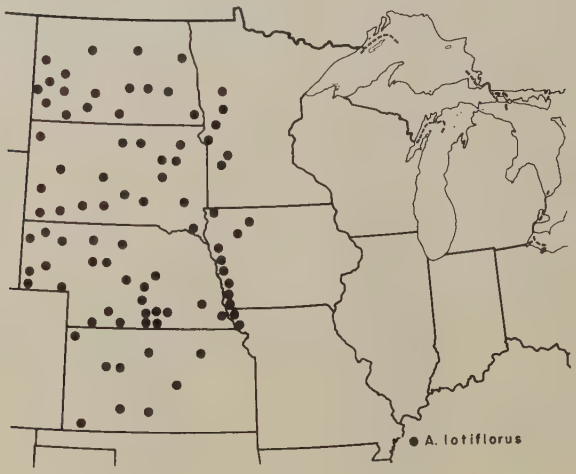
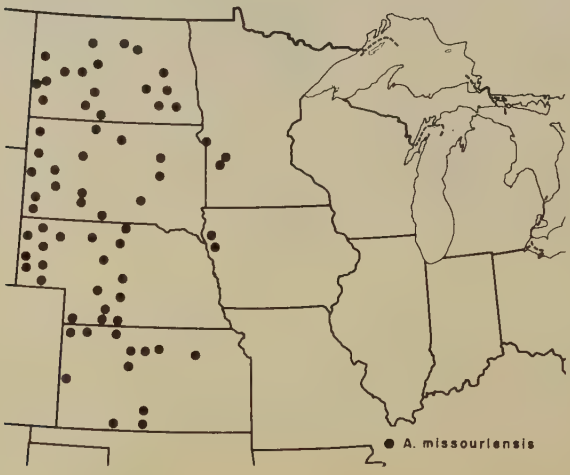


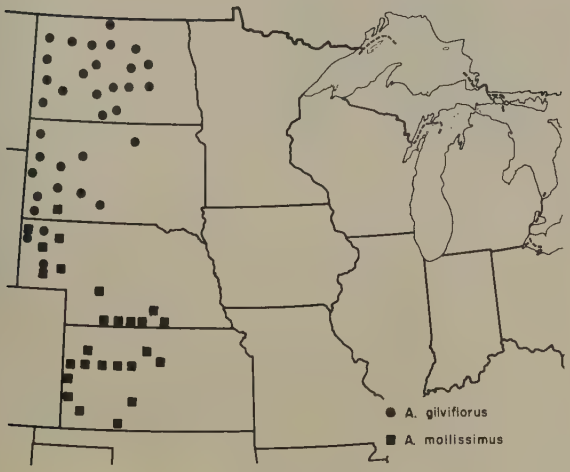
Plate X. Astragalus mollissimus, A. Inflorescence and leaf. B. Fruit.



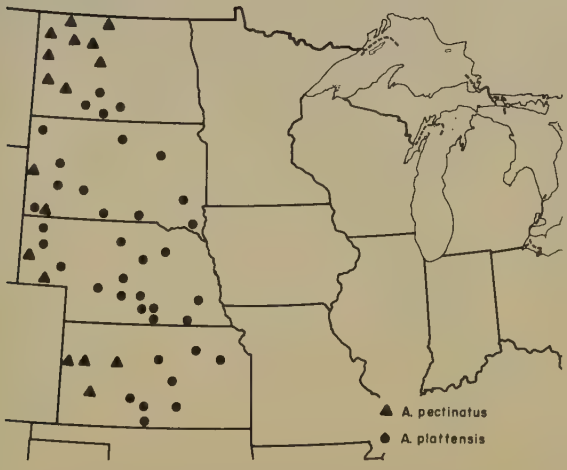
Map 9. Range of Astragalus lotiflorus.



Map 10. Range of Astragalus missouriensis.



Map 11. Range of Astragalus gilviflorus and A. mollissimus.



Map 12. Range of Astragalus pectinatus and A. plattensis.

Stems 20-50 cm long, several to many from a branching woody caudex, ascending to erect, strigose throughout with simple hairs. Stipules 4-10 mm, connate-clasping, the lower ones fused through half their length or more, ovate, acuminate, glabrous to strigose, ciliate. Leaves 4-9 cm, the petiole almost lacking; leaflets 7-17, 22-70 mm long, 1-3 mm wide, linear, decurrent with the rachis, the terminal one merely a continuation of the rachis. Peduncles 2-10 cm, coarse, strigose. Bracts lanceolate, sparsely strigose with at least some black hairs, longer than the pedicels. Racemes 3-10 cm, at first tightly clustered, later elongating and becoming lax, little elongating in fruit. Flowers 18-22 mm, whitish or yellowish; the keel immaculate. Calyx cylindric, strigose; tube 5.6-8.8 mm; teeth 1.2-2.1 mm, narrowly triangular. Pods 11-23 mm, oblong to ovoid, fleshy when young, becoming woody in age, 1-celled, cross-ribbed, glabrous, sessile, dehiscent, reflexed; both sutures prominent.

The calyx teeth and bracts are commonly black hairy but many specimens bear only white pubescence on these members.

The type specimen of A. pectinatus has not been seen by the writer. However, a Douglas specimen labeled A. pectinatus has been examined (OXF). It agrees closely with the material from the north-central states, and with the description and plate of Phaca pectinata (Hooker, 1830).

Although the name A. pectinatus Douglas was published (as a synonym) prior to the combination A. pectinatus (Hook.) Don, it does not have priority in nomenclature. Because both names are evidently based on the same type the second name (by definition, Art. 64, Inter. Code, 1956) cannot be rejected as a later homonym; it must therefore be taken up as the name of the species.

Beyond our region this species occurs from Alberta and Saskatchewan south to Colorado. The habitat of this plant is restricted to seleniferous soils (Trelease and Beath, 1949). It is commonly found in low areas along drainages and along fence-rows and roadsides where the soil has been disturbed. A. pectinatus possesses the rank odor (sometimes said to be "snake-like") typical of seleniferous plants.

This very handsome species flowers from May in the southern part of the range to early July in the northern part.

The somatic chromosome number of A. pectinatus has been reported to be 22 by both Vilkomerson (1943) and Ledingham (1957).

*Astragalus plattensis Nutt. (Map 13. Plate XI, Figs. C, D)

Astragalus plattensis Nutt. ex T. and G., Fl. N. Am. 1:332. 1838.
Astragalus pachycarpus T. and G. Fl. N. Am. 1:332. 1838.
Tragacantha plattensis (Nutt.) Kuntze Rev. Gen. 947. 1891.
Phaca plattensis (Nutt.) MacMil. Metasp. Minn. Valley 325. 1892. pro syn.
Astragalus crassicarpus var. pachycarpus (T. and G.) M.E. Jones Contr. West. Bot. 8:16. 1898.
Geoprumnon plattense (Nutt.) Rydb. ex Small. Fl. SE. U.S. 616. 1903.
Geoprumnon pachycarpus (T. and G.) Rydb. ex Small, Fl. SE. U.S. 616. 1903.

Plate XI. Astragalus pectinatus, A. Inflorescence and leaves. B. Fruit. Astragalus plattensis, C. Section of stem with inflorescence and leaf. D. Fruit. Astragalus purshii, E. Inflorescence and leaf. F. Fruit.

Stems 10-30 cm long, from a creeping rhizome, decumbent to ascending, villous with simple hairs. Stipules 5-9 mm, clasping, ovate to lanceolate or triangular, glabrous to sparsely strigose dorsally, ciliate. Leaves 5-9 (15) cm; leaflets 13-29, 9-16 mm long, 3-8 mm wide, elliptic to oval, acute or obtuse, strigulose above and below with simple hairs. Peduncles 3-8 (9) cm long, villous. Bracts narrowly lanceolate, longer than the pedicels. Racemes 1-3 cm long, few-flowered, subcapitate. Flowers 14-18 mm, purplish, spreading. Calyx cylindric, sparsely villous; tube 6.0-7.5 mm; teeth 2.0-3.5 mm, linear-subulate. Pods 13-20 mm, ovoid-acuminate, with a stout beak, 2-celled, subsessile, strigose with simple hairs; the upper (ventral) suture sulcate.

The relationships of A. plattensis appear to lie with the Sarcocarpi. It can be distinguished from other members of that section on the basis of its rhizomatous habit, and ovoid-acuminate, strigose pods.

The synonymy of this species has recently been enlarged by the addition of A. pachycarpus and its segregates (Barneby, 1956a). Although A. pachycarpus and A. plattensis were published simultaneously there has never been any doubt as to the application of A. plattensis. However, the application of A. pachycarpus has been confused from the first. Gray (1864) thought it might be a depauperate form of A. caryocarpus. Jones (1923) treated it as a variety of A. crassicarpus. Barneby's review of the typification of A. pachycarpus (loc. cit.) leaves little doubt as to the dispotition of this entity.

Beyond the limits of our region the species extends westward into Wyoming and south to Texas. The plants grow in sandy areas along drainages, slopes, and flats in the prairies and plains. The blooming period extends from late April to late June.

*Astragalus purshii Dougl. (Plate XI, Figs. E, F)

Astragalus purshii Dougl. ex Hook., Fl. Bor. Am. 1:152. 1834.
*Phaca mollissima Nutt. ex T. and G., Fl. N. Am. 1:350. 1838.
non A. mollissimus Torr. 1838.
Tragacantha purshii (Dougl.) Kuntze Rev. Gen. 947. 1891.
Xylophacos purshii (Dougl.) Rydb. Bull. Torrey Club 32:662. 1905.
Phaca purshii (Dougl.) Piper Contr. U.S. Nat. Herb. 11:369. 1906.
*Astragalus purshii var. interior Jones Rev. Astrag. 222. 1923.
Xylophacos incurvus Rydb. Bull. Torrey Club 52:366. 1925.
Astragalus purshii var. incurvus (Rydb.) Jepson Fl. Cal. 2:360. 1936.
Astragalus incurvus (Rydb.) Abrams Ill. Fl. Pac. St. 2:566. 1944.

Plants caespitose; stems 5-9 cm, poorly developed, commonly covered by leaf-bases and stipules, several to many from a branching caudex. Stipules 5-8 mm, free, ovate to lanceolate, obtuse, densely villous on the dorsal surface. Leaves 3-9 cm, densely villous to lanate throughout with simple hairs; leaflets 7-15, 6-12 mm long, 2-4 mm wide, elliptic to oblong or obovate, obtuse. Peduncles 2-8 cm, at first ascending, later prostrate, villous. Bracts ovate to lanceolate, villous. Racemes to 3 cm, subcapitate, few- to several-flowered, little elongating

in fruit. Flowers 20-25 mm, yellowish, the keel purple-tipped. Calyx cylindric, villous; tube 9.0-1-.0 mm, teeth 1.4-6.0 mm, triangular-subulate, black-hairy. Pods 10-20 mm, straight or curved, oblong, densely woolly-villous, 1-celled, sessile.

The species was based on materials collected "on the low hills of the Spokane River, North-West America" (Hooker, 1834) by Douglas. The writer has examined an authentic Douglas specimen of A. purshii (OXF) from "N.W. America" (probably an isotype) and finds that it falls within the limits of the species as presently interpreted.

Only a single collection of A. purshii is known from our region; it was collected by Carr at Newell, Butte County, South Dakota. According to Barneby's (1947b) detailed subspecific classification, the sheet represents the "typical" form, i.e. var. purshii. Stevens (1950) also has reported A. purshii from the western part of North Dakota, but the specimens prove to be the hairy A. lotiflorus var. nebraskensis. A. purshii is widespread west of our range.

The plants grow on hillsides, valleys, and prairies. The flowering period extends from late April to early June.

Astragalus racemosus Pursh (Map 13. Plate XII, Figs. A-D)

Astragalus racemosus Pursh Fl. Am. Sept. 740. 1814.
Astragalus galegoides Nutt. Gen. 2:100. 1818.
Tragacantha racemosa (Pursh) Kuntze Rev. Gen. 947. 1891.
*Astragalus racemosus var. brevisetus M.E. Jones Proc. Cal. Acad. II. 5:662. 1895.
*Astragalus racemosus var. longisetus M.E. Jones Proc. Cal. Acad. II. 5:662. 1895.
Tium racemosum (Pursh) Rydb. Bull. Torrey Club 32:659. 1905.
Tium platycarpum Rydb. N. Am. Fl. 24:387. 1929.
Astragalus racemosus var. typicus C.L. Porter Madrono 8:99. 1945.
*Astragalus racemosus var. treleasei C.L. Porter Madrono 8:99. 1945.

Stems 24-60 cm long, several to many in clumps from a branching woody caudex, strigose with malpighian hairs that are attached very near to one end. Stipules 5-10 mm long, the lower ones connate-clasping, the upper ones free, triangular, strigose, fragile. Leaves 6-14 cm long; leaflets 13-27, 15-32 mm long, 4-8 mm wide, narrowly elliptic to oblong or narrowly lanceolate, glabrous above, strigose below. Peduncles 4-13 cm long, strigose. Bracts scarious, narrowly lanceolate, longer than the pedicels. Racemes 3-15 cm long, elongating at maturity, several- to many-flowered. Flowers 13-17 mm, yellowish; the keel not usually maculate. Calyx cylindric, strigose, tube 5.0-7.0 mm long, teeth (1.5) 2.0-6.0 (8.0) mm, narrowly triangular to linear. Pods 24-34 mm, narrowly oblong, cordate in cross-section, glabrous (rarely strigose), 1-celled; the upper suture prominent, the lower one sulcate; stipe 4-8 mm long.

The most notable variation in A. racemosus involved the length of the bracts, length of the calyx teeth, and the vesture of the pod. In 1895

Jones described two varieties of A. racemosus based largely on bract characters. In the variety longisetus the narrowly lanceolate bracts are longer than the calyces. The type of variety brevisetus has bracts that equal the length of the pedicels and are ovate in shape. These entities represent the extremes of a wide range of variation and possibly do not deserve varietal status.

The calyx teeth are frequently shorter in specimens from Kansas and southern Nebraska than in those from North Dakota. However, the specimen having the longest calyx teeth of any examined by the writer was from Kansas.

The pods are usually glabrous, but plants from widely scattered areas have strigose pods. There does not seem to be a correlation between pod strigosity and other characteristics of the species.

As pointed out previously (under A. drummondii) A. racemosus has traditionally been placed with A. drummondii in the section Galegiformes. However, A. racemosus has more points of similarity with A. bisulcatus (usually placed in the Bisulcati) than with A. drummondii. A. racemosus and A. bisulcatus possess the same habit of growth, and the same chromosome number. Both are selenium accumulators. The pods are alike in being stipitate, but those of A. bisulcatus are characterized by two furrows running the length of the ventral surface rather than a dorsal invagination.

Astragalus racemosus and A. canadensis are sometimes confused in early flower. The stipe on the ovary of A. racemosus is distinct even during early anthesis; the ovary of A. canadensis is sessile.

Beyond our range the plants extend from Saskatchewan south to New Mexico and Texas. They grow in clay, calcareous, or sandy soil along drainages and ravines and are also common in low prairies. Disturbed places where the topsoil has been removed, as along roadsides and washes, are frequently covered by great numbers of plants.

The species under discussion has been listed by Trelease and Beath (1949) as a primary selenium indicator. Although the plants are seldom eaten by livestock they can cause serious poisoning.

A. racemosus has a distinctive odor which is characteristic of seleniferous plants (Beath, 1937). Nuttall (1818) noted the disagreeable odor in his description of A. galegoides.

The blooming period extends from late April in Kansas to late August in North Dakota. The handsome clump-forming plants bearing long racemes of whitish flowers present a striking appearance.

A somatic chromosome number of 24 has been reported for A. racemosus by both Vilkomerson (1943) and Ledingham (1957).

Astragalus sericoleucus A. Gray (Map 7. Plate XIII, Figs. A, B)

Astragalus sericoleucus A. Gray Am. Jour. Sci. II. 33:410. 1862.
*Phaca sericea Nutt. ex T. and G., Fl. N. Am. 1:343. 1838. non A. sericea DC. 1802.
Tragacantha sericea (Nutt.) Kuntze Rev. Gen. 942. 1891.
Orophaca sericea (Nutt.) Britt. ex Britt. and Brown, Ill. Fl. 2:307. 1897.

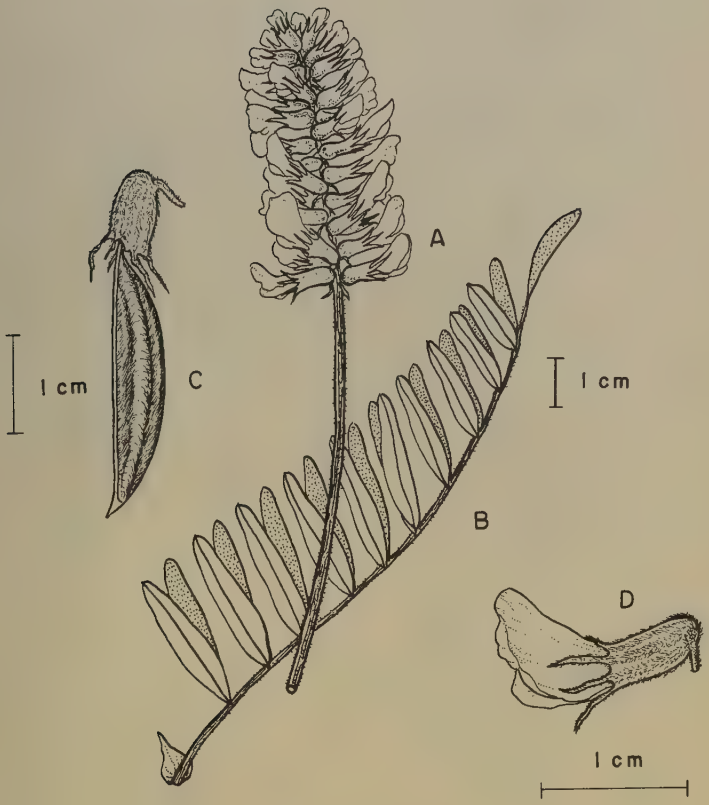
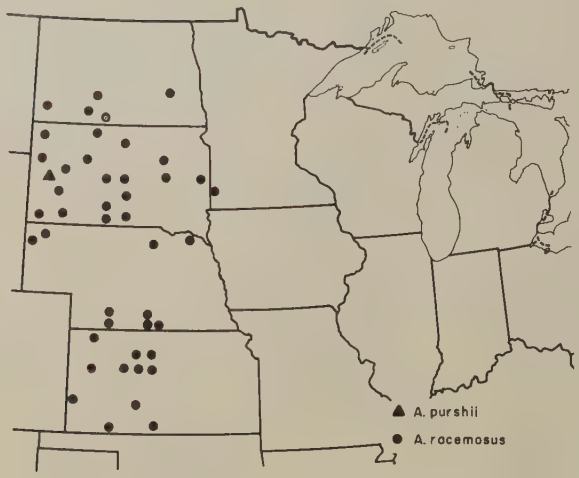


Plate XII. Astragalus racemosus, A. Inflorescence. B. Leaf. C. Fruit. D. Flower.



Map 13. Range of Astragalus purshii and A. racemosus.

Map 14. Range of Astragalus spatulatus.

Plate XIII. Astragalus sericoleucus, A. Plant with leaves and inflorescences. B. Leaf. Astragalus spatulatus, C. Plant with leaves, flowering raceme and fruiting raceme. Astragalus striatus, D. Inflorescence and leaf. E. Fruit.

Plants pulvinately caespitose. Stems 1-8 cm long, spreading, several from a woody taproot, covered by stipules and leaf bases. Stipules 5-10 mm, connate-clasping, ovate, villous with malpighian hairs. Leaves palmately trifoliolate, occasionally 5-foliolate, 1-2 cm long; leaflets 5-8 mm long, spatulate, silvery-strigose with malpighian hairs. Peduncles 1-2 cm long, strigose. Bracts longer than the pedicels, lanceolate-subulate, hyaline. Racemes 2- to 4-flowered. Flowers 6-8 mm long, purple. Calyx densely pilose with malpighian hairs, campanulate; tube 2.0-3.0 mm, teeth 1.0-2.2 mm, triangular-subulate. Pods 5-6 mm long, lance-ovoid, densely pilose, sessile.

A. sericoleucus appears to be closely related to A. barrii. These two species constitute the north-central states representatives of that series of the Triphylli which have pedunculate inflorescences and purplish flowers.

The species occurs westward from our region through eastern Wyoming and eastern Colorado. The plants grow on the high plains along exposed bluffs and ravines in the short-grass prairie. The blooming period extends through May and June.

Astragalus spatulatus Sheld. (Map 14. Plate XIII, Fig. C)

Astragalus spatulatus Sheld. Minn. Bot. Stud. 1:22. 1894.
*Homalobus caespitosus Nutt. ex T. and G., Fl. N. Am. 1:352. 1838.
*Homalobus canescens Nutt. ex T. and G., Fl. N. Am. 1:352. 1838. non A. canescens DC. 1802.
*Homalobus brachycarpus Nutt. ex T. and G., Fl. N. Am. 1:352. 1838. non A. brachycarpus Bieb. 1809.
Astragalus caespitosus (Nutt.) A. Gray Proc. Am. Acad. 6:230. 1864. non A. caespitosus Pallas 1800.
Tragacantha caespitosa (Nutt.) Kuntze Rev. Gen. 943. 1891.
Astragalus simplicifolius var. caespitosus (Nutt.) M.E. Jones Proc. Cal. Acad. II. 5:647. 1895.
Astragalus simplicifolius var. spatulatus (Sheld.) M.E. Jones Contr. West. Bot. 10:65. 1902.
Astragalus simplex Tidestr. Contr. U.S. Nat. Herb. 25:330. 1925.
Astragalus spatulatus var. simplex (Tidestr.) Tidestr. Proc. Biol. Soc. Wash. 50:20. 1937.

Plants pulvinately caespitose. Stems prostrate, several from a branching caudex. Stipules 6-12 mm long, connate-clasping, hyaline, strigose with malpighian hairs or glabrous, ciliate or smooth. Leaves 2-5 cm long, unifoliolate (rarely some of them trifoliolate), narrowly spatulate, acute, strigose above and below with malpighian hairs. Peduncles 3-7 cm long, appressed strigose. Bracts with a midvein, the margins hyaline, narrowly lanceolate, longer than the pedicels, strigose along the midvein, ciliate. Racemes 1-3 cm long, few- to several-flowered, subcapitate. Flowers 7-9 mm long, purple or ochroleucous. Calyx campanulate, strigose with malpighian hairs; tube 2.0-2.6 mm; teeth 1.5-2.5 mm, linear-subulate. Pods 10-15 mm long, sessile, linear-oblong, laterally compressed, 1-celled, strigose with malpighian hairs; both sutures prominent; the valves coiling in dehiscence.

A. spatulatus varies in stature, leaflet number and texture, and in flower color. The plants are most commonly low-growing and reach a height of from 5-8 cm; exceptionally they grow to 12 cm. To the west of our area the plants are occasionally less than 3 cm tall, and are packed together in dense mats.

Leaflet number varies from one to three (rarely five), but generally only a single leaflet is produced. The leaves may be thin and narrowly spatulate or thick and broad. The flowers are most frequently a dark pink-purple color, but plants bearing yellowish colored flowers are not uncommon.

It is possible that one might confuse the plants of A. spatulatus which bear three leaflets with the members of the Triphylli, but the light green color of the leaves, the narrowly spatulate leaflets, and linear-oblong pods distinguish it from the members of that section.

Sheldon (1894) recognized the lack of a name in Astragalus for Homalobus caespitosus Nuttall and for the other segregates (H. canescens and H. brachycarpus) which did not differ enough to warrant specific rank. His A. spatulatus is based on Homalobus caespitosus. Our material closely matches the type of H. caespitosus.

For some time Phaca simplicifolia Nuttall (a different species) was confused with A. spatulatus and this accounts for the treatment by Jones (1895, 1902, 1923; see synonymy above). In 1925 Tidestrom distinguished between H. brachycarpus and A. spatulatus and proposed the name A. simplex to replace the former. Later (1937) he reduced this species to varietal status under A. spatulatus.

Beyond our region A. spatulatus extends from Saskatchewan and Alberta south to Utah and Colorado. The plants grow in open stretches of soil on bluffs and ravines, and on hills in the short-grass prairies, commonly associated with the members of the Triphylli. The flowering period extends from May through June.

The somatic chromosome number of A. spatulatus is reported to be 24 (Ledingham, 1957).

Astragalus striatus Nutt. (Map 15. Plate XIII, Figs. D, E)

Astragalus striatus Nutt. ex T. and G., Fl. N. Am. 1:330. 1838.
Astragalus laxmanni sensu Nutt. Gen. 2:99. 1818. non A. laxmanni Jacq. 1776.
Astragalus adsurgens sensu authors. non A. adsurgens Pallas 1800.
*Astragalus adsurgens var. β robustior Hook. Fl. Bor. Am. 1:149. 1834.
Astragalus nitidus Dougl. ex Hook., Fl. Bor. Am. 1:149. 1834. pro syn.
Astragalus adsurgens var. pauperculus Blankin. Mont. Agr. Coll. Stud. 1:72. 1905.
Astragalus adsurgens var. albiflorus Blankin. Mont. Agr. Coll. Stud. 1:71. 1905.
Phaca adsurgens sensu Piper Contr. U.S. Nat. Herb. 11:372. 1906.
*Astragalus chandonnetii Lunell Am. Midl. Nat. 2:127. 1911.

Astragalus nitidus var. robustior (Hook.) M.E. Jones Rev. Astrag. 170. 1923.
Astragalus striatus forma chandonetti (Lunell) Moore Rhodora 59:8. 1957.

Stems 15-45 cm long, decumbent to erect, several to many from a caudex, strigose with malpighian hairs. Stipules 6-10 mm long, chartaceous, connate-clasping, the free ends lanceolate to triangular-subulate, strigose on the dorsal surface. Leaves 6-12 cm long; leaflets 15-23, 13-28 mm long, 3-9 mm wide, oblong to elliptic, acute or obtuse, strigose throughout with malpighian hairs. Peduncles 6-16 cm long, equalling or shorter than the subtending leaves. Bracts ovate-lanceolate, longer than the pedicels. Racemes 2-6 cm long, few- to several-flowered, subcapitate. Flowers 13-16 mm long, purplish or occasionally yellowish or white. Calyx short-cylindric, strigose with dark and light hairs; tube 5-6 mm long; teeth 2.0-4.0 mm long, linear-subulate. Pods 7-12 mm long, sulcate on the lower (dorsal) suture, 2-celled, erect, sessile, strigose.

This widespread species shows considerable variation in flower color, number of flowers, and in the shape and texture of the leaflets. A. chandonetti was based upon a form having yellowish flowers and variety albiflorus on a form with white flowers. The number of flowers and the shape and texture of the leaflets seem to be the result of response to the environment. Plants from more favorable sites frequently possess a large number of flowers and thicker, broader leaflets.

Nuttall (1818) treated A. striatus under the name A. laxmanni, a European species described by Jacquin in the Hortus Botanicus Vindobonensis (1776). The figure of A. laxmanni in that publication (tab. 37) is of a very slender plant which seems beyond the circumscription of A. striatus, at least as represented in this country.

Hooker (1834) identified our material as A. adsurgens Pallas (another European taxon), and that name became well established in the literature of North American botany. Pallas' figure of A. adsurgens is similar in many features to A. striatus and it is possible that the latter is merely an American extension of the total adsurgens complex. However, until it is possible to examine Asiatic and European material critically, a definitive solution to the problem is not possible.

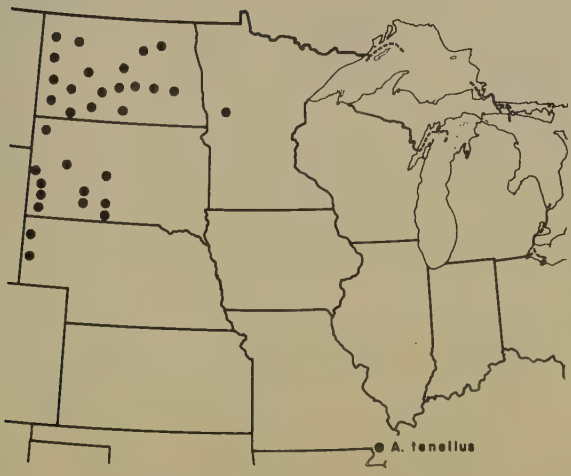
A. striatus extends from the Northwest Territories and Alaska in the north to Colorado in the south. The plants occur mostly in upland situations along bluffs and ravines in short-grass prairie regions. The blooming period extends from early June to mid-August.

According to Ledingham (1957) the somatic chromosome number of A. striatus is 32.

Astragalus tegetarius S. Wats. (Map 17. Plate XV, Fig. A)

Astragalus tegetarius S. Wats. Bot. King. Expl. 76. 1891.
Kentrophyta montana Nutt. ex T. and G., Fl. N. Am. 1:353. 1838. non A. montanus L. 1753.
Kentrophyta viridis Nutt. ex T. and G., Fl. N. Am. 1:353. 1838. non A. viridis Bunge 1869.

Map 15. Range of Astragalus striatus.



Map 16. Range of Astragalus tenellus.

Astragalus kentrophyta A. Gray Proc. Acad. Phila. 1863:60. 1863. nom. illegit.
Tragacantha montana (Nutt.) Kuntze Rev. Gen. 941. 1891.
Phaca viridis (Nutt.) Britt. Mem. Torrey Club 5:291. 1894.
Astragalus viridis (Nutt.) Sheld. Minn. Bot. Stud. 1:118. 1894. non A. viridis Bunge 1869.
Homalobus montanus (Nutt.) Britt. ex Britt. and Brown, Ill. Fl. 2:306. 1897.
Astragalus montanus (Nutt.) M.E. Jones Rev. Astrag. 80. 1923. non A. montanus L. 1753.
Astragalus tegetarius var. viridis (Nutt.) Barneby Leafl. West. Bot. 4:97. 1951.

Stems 5-30 cm long, prostrate or decumbent, mat-forming, several from a branching caudex, strigose with malpighian hairs. Stipules 3-7 mm long, connate-clasping, ovate, awned-subulate, strigose or glabrous, ciliate. Leaves 1-2 cm long; leaflets 5-7, 8-12 mm long, strigose to strigulose, linear-subulate, awn-tipped. Racemes short-pedunculate or sessile; flowers 1-3, 5-6 mm long, purplish or whitish with a purple-tipped keel. Bracts longer than the pedicel, acute, lanceolate, ciliate, herbaceous. Calyx campanulate, white pilose; tube 1.8-2.7 mm; teeth 1-2 mm, narrowly triangular. Pods 5-7 mm long, narrowly oblong, straight, strigose to pilose, 1-celled, sessile, laterally compressed; both sutures prominent.

The relationship of A. tegetarius to the other members of the section Homalobi appears to be through A. vexilliflexus. Some of the montane forms of A. vexilliflexus are almost indistinguishable from A. tegetarius. In our area the latter is distinctive on the basis of the subulate, awn-tipped leaflets, extremely short pedunculate or sessile inflorescences and one- to three-flowered racemes.

When Nuttall described Kentrophyta montana and K. viridis (T. and G., 1838) the name montanus was already occupied in Astragalus. Gray, in his revision of the genus Astragalus in 1864, included both of the species of Kentrophyta in a single species under the name of Astragalus kentrophyta. He had earlier (1863) applied this name to K. montana alone and had presumably recognized that the name montana was occupied in Astragalus. However, when he placed K. viridis with K. montana he should have taken up the name viridis (unoccupied at that time) for the species. The name A. kentrophyta then becomes an illegitimate name (Art. 70, par. 1, Inter. Code, 1956). The earliest available name then is A. tegetarius S. Wats.

According to Barneby (1951a) this species is represented in our region by the variety viridis. The above list of synonymy includes only those names involved with variety viridis.

As only a small part of the total tegetarius complex is included within the north-central states it is not practical in the present paper to attempt to evaluate the western subspecific categories.

The species is widespread in the western United States. It extends from Alberta, south and west to California and Arizona. The plants grow in more open areas along bluffs and ravines in our region. The flowering period extends throughout June and July.

Astragalus tenellus Pursh (Map 16. Plate XIV, Figs. B, C)

Astragalus tenellus Pursh Fl. Am. Sept. 2:473. 1814. (*fide Pursh 1814)
*Ervum multiflorum Pursh Fl. Am. Sept. 2:739. 1814.
*Orobus dispar Nutt. Gen. 2:95. 1818.
Phaca nigrescens Hook. Fl. Bor. Am. 1:143. 1830.
Physondra dispar (Nutt.) Raf. Atl. Jour. 145. 1830.
Homalobus dispar (Nutt.) Nutt. ex T. and G., Fl. N. Am. 1:350. 1838.
Homalobus multiflorus (Pursh) T. and G. Fl. N. Am. 1:350. 1838.
Homalobus nigrescens Nutt. ex T. and G., Fl. N. Am. 1:350. 1838. pro syn.
Astragalus nigrescens (Hook.) A. Gray Am. Jour. Sci. II. 33:410. 1862. non A. nigrescens Pallas 1800.
Astragalus multiflorus (Pursh) A. Gray Proc. Am. Acad. 6:226. 1864.
Tragacantha tenella (Pursh) Kuntze Rev. Gen. 942. 1891.
Astragalus acerbus Sheld. Minn. Bot. Stud. 1:123. 1894.
Homalobus tenellus (Pursh) Britt. ex Britt. and Brown, Ill. Fl. 2:305. 1897.
Homalobus clementis Rydb. Bull. Torrey Club 31:563. 1894.
Homalobus acerbus (Sheld.) Rydb. Bull. Torrey Club 32:666. 1905.
*Homalobus stipitatus Rydb. Bull. Torrey Club 34:419. 1907.
*Homalobus strigulosus Rydb. Bull. Torrey Club 34:420. 1907.
Astragalus tenellus forma strigulosus (Rydb.) Macbr. Contr. Gray Herb. 65:35. 1922.
Astragalus tenellus forma acerbus (Sheld.) Macbr. Contr. Gray Herb. 65:35. 1922.
Astragalus tenellus var. clementis (Rydb.) Macbr. Contr. Gray Herb. 65:35. 1922.
Astragalus tenellus var. strigulosus (Rydb.) Herm. Jour. Wash. Acad. Sci. 38:237. 1948.

Stems 23-54 mm long, several from a branching caudex, decumbent to ascending, strigose throughout with simple hairs. Stipules 2-6 mm long, connate-clasping, strigose to glabrous on the dorsal surface, the free ends triangular, often blackening on drying. Leaves 5-8 cm long, petioles short or lacking; leaflets 15-21, 8-20 mm long, 2-4 mm wide, linear-oblong to narrowly lanceolate or elliptic, obtuse or acute, strigose below, glabrous above. Peduncles 1-4 cm long, strigose, shorter than the racemes, occasionally in pairs. Bracts ovate, ciliate, shorter or longer than the pedicels. Racemes 3-10 cm long, several- to many-flowered, elongating at maturity. Flowers 7-9 mm long, ochroleucous (rarely purplish); the keel purple-tipped. Calyx campanulate, strigose; tube 2.0-2.5 mm long, teeth 0.9-1.7 mm long, triangular. Pods 12-18 mm long, laterally compressed and nearly flat, 1-celled, dehiscent, glabrous (in ours); both sutures prominent; stipe 1-5 mm long.

The writer has seen the type of Ervum multiflorum (PH). It agrees closely with the material herein treated as A. tenellus. Pursh (1814), in speaking of E. multiflorum, noted that "of this plant I had an imperfect specimen in the Lewisian Herbarium, together with some pods of an Astragalus, which led me into the error of placing it under that genus;

Plate XIV. Astragalus vexilliflexus, A. Section of stem with leaf and inflorescence. Astragalus tenellus, B. Section of stem with leaves and inflorescences. C. Fruit.

but having since seen fine specimens in the collection of Mr. Bradbury, I was enabled to correct this error." This statement gives at least indirect evidence as to the typification of A. tenellus.

Since both names (A. tenellus and E. multiflorum) were published at the same date some authors (e.g. Gray, 1864) have taken up the name multiflorus for this species. Indeed, the author who first unites taxa bearing names or epithets of the same date has the right to choose one of them, and his choice must be followed. However, Pursh only altered the circumscription of the taxon and transferred it to the genus Ervum. He should have retained the epithet tenellus (Art. 51, 55, Inter. Code, 1956). Thus, the name A. tenellus is maintained in the present treatment.

This wide-ranging complex varies in several characteristics. The pods are normally short-stipitate and glabrous, but they are not infrequently long-stipitate and they may also be strigose. Homalobus stipitatus, based on plants collected along the upper Missouri by Geyer, is merely a long-stipitate form. H. strigulosus (isotype US) was based on material which differs from the more common form of the species only in its strigose pods. An isotype of H. clementus (US) has strigose, short-stipitate pods and purplish flowers.

Although not closely related A. flexuosus is not infrequently confounded with A. tenellus; the laterally flattened pods, peduncles shorter than the racemes, and stipules which blacken on drying are diagnostic of the latter.

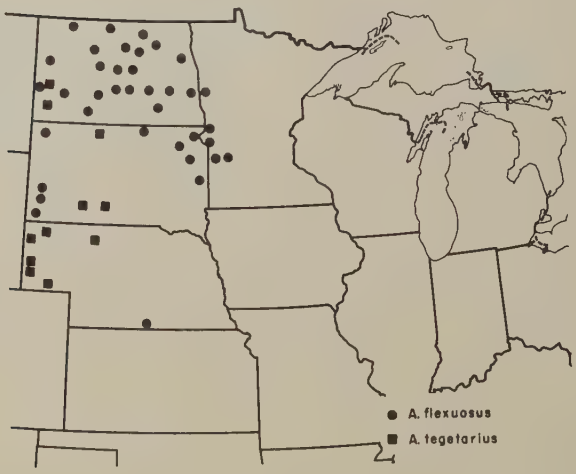
A. tenellus extends from the Yukon Territories and Alaska southward through the mountains to New Mexico. The plants occur in badlands on saline soil, along dry hillsides, gravelly beaches, and in the prairies. They also occur at higher elevations in forest areas. The blooming period extends from early June to late July or early August.

The somatic chromosome number of A. tenellus has been reported to be 24 (Ledingham, 1957).

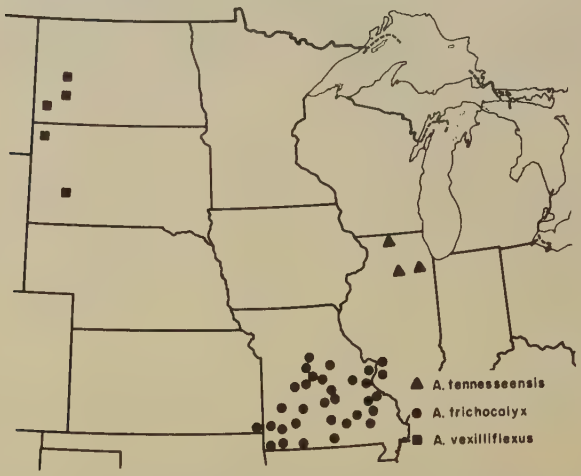
*Astragalus tennesseensis A. Gray (Map 18. Plate XV, Figs. B, C)

Astragalus tennesseensis A. Gray ex Chapm., Fl. S. States 98. 1860.
Astragalus plattensis var. tennesseensis (A. Gray) A. Gray Proc. Am. Acad. 6:193. 1864.
Astragalus plattensis var. missouriensis Boltwood ex Coulter, Bot. Gaz. 5:71. 1880.
Geoprumnon tennesseensis (A. Gray) Rydb. ex Small, Fl. SE. U.S. 615. 1903.

Stems 10-40 cm long, several from a woody caudex, decumbent to ascending, villous with spreading simple hairs. Stipules 12-17 mm long, foliose, connate-clasping below, the upper ones free, ovate, acuminate, villous. Leaves 6-13 cm long, short-petiolate; leaflets 21-37, 10-23 mm long, oblong to elliptic, obtuse or truncate, villous below, glabrous above. Peduncles 3-13 cm long, villous. Bracts narrowly lanceolate, much longer than the pedicels. Racemes 2-5 cm, closely several-flowered, little elongating in fruit. Flowers 14-19 mm long, yellowish or whitish. Calyx cylindric, gibbous at the base, white-villous; tube 6.5-8.0 mm long; teeth 2.0-4.0 mm long, triangular. Pods 23-30 mm



Map 17. Range of Astragalus flexuosus and A. tegetarius.



Map 18. Range of Astragalus tennesseensis, A. trichocalyx, and A. vexilliflexus.

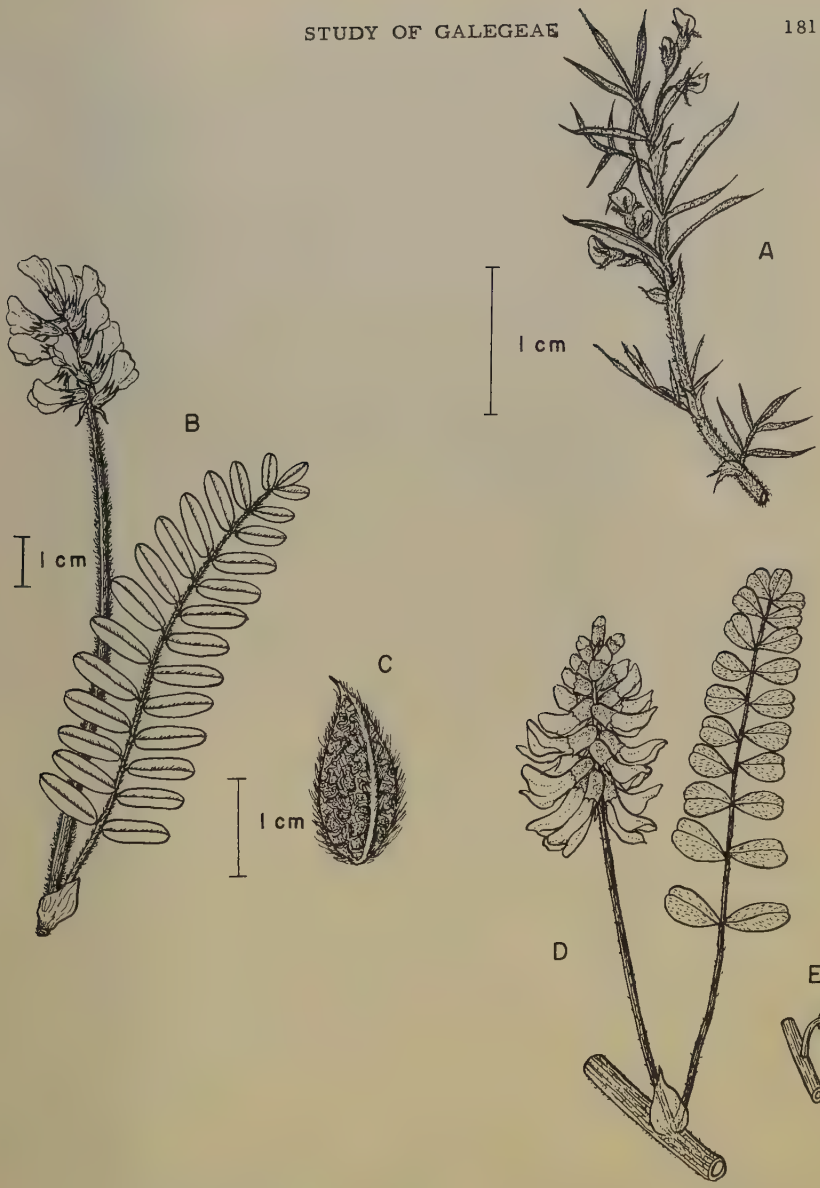


Plate XV. Astragalus tegetarius, A. Section of plant with leaves and inflorescences. Astragalus tennesseensis, B. Inflorescence and leaf. C. Fruit. Astragalus trichocalyx, D. Inflorescence and leaf. E. Fruit.

long, lance-ovoid, fleshy, 2-celled, sessile, villous, cross-ridged in a reticulate pattern.

A. tennesseensis has several features which readily distinguish it from the related members of the Sarcocarpi. It may be distinguished from both A. crassicarpus and A. trichocalyx by its long-villous, cross-reticulate pods and from A. plattensis by its longer pods and habit of growing from a caudex. It also bears long-villous hairs throughout the stems and leaves, which, in addition to its large foliose stipules, can be used to distinguish the plants in vegetative condition.

Gray (Chapman, 1860) described A. tennesseensis from plants collected on hills near Nashville, Tennessee by Lesquereux and at Lagrange, Alabama by Hatch (type, GH). He later (1864) reduced the species to varietal status under A. plattensis, but later authors have maintained it as a distinct species. Barneby (1956a) believes that it is not only a distinct species but it may well form a type of a section apart.

Beyond our region it is known from Tennessee and from Alabama. The plants grow in open woodlands and on barren calcareous soils. They flower from mid-April to late May.

*Astragalus trichocalyx Nutt. (Map 18. Plate XV, Figs. D, E)

Astragalus trichocalyx Nutt. ex T. and G., Fl. N. Am. 1:332. 1838.
Astragalus mexicanus sensu A. Gray Pl. Wright. 1:51. 1852. pro parte. non A. mexicanus A. DC. 1833.
Geoprumnon mexicanus sensu Rydb. ex Small, Fl. SE. U.S. 616. 1903.
Geoprumnon trichocalyx (Nutt.) Rydb. Bull. Torrey Club 53:163. 1926.
Astragalus mexicanus var. trichocalyx (Nutt.) Fern Rhodora 39:317. 1937.
Astragalus crassicarpus var. trichocalyx (Nutt.) Barneby Am. Midl. Nat. 55:499. 1956.

Stems 14-76 cm long, decumbent to erect, robust (rarely very slender), sparsely short-villous, several from a branching woody caudex. Stipules 5-13 mm long, connate-clasping on the lower nodes, the upper ones free, triangular-subulate, glabrous, ciliate. Leaves 7-15 cm long, short-petiolate; leaflets 19-35, 8-25 mm long, 3-9 mm wide, narrowly lanceolate to elliptic or linear-oblong, dimorphic, the early leaflets shorter and retuse or truncate, the later ones longer and obtuse or acute, villous below, glabrous or sparsely villous above. Peduncles 4-10 (15) cm long, robust, villous. Bracts linear-oblong, acute, longer than the pedicels. Racemes 2-6 cm, few- to several-flowered, subcapitate, little elongating in fruit. Flowers 15-23 mm, ochroleucous, the keel purple-tipped. Calyx cylindric, white woolly-villous or lanose; tube 6.0-8.2 mm; teeth 1.5-3.4 mm, triangular. Pods 18-30 mm long, 15-19 mm wide, obovoid to subglobose, thick and fleshy, 2-celled, glabrous, sessile.

The stature of A. trichocalyx varies greatly during the growing season. The plants begin to flower when they are only a few centimeters in height. They then elongate rapidly throughout flowering and fruiting.

Flowering specimens of A. trichocalyx are easily distinguished from

those of A. crassicarpus by their white soft lanose pubescent calyces and light colored flowers. The more robust nature of A. trichocalyx, though difficult to define objectively, cannot be discounted. In fruiting specimens the problem of separation is more difficult; usually A. trichocalyx can be distinguished by its large size and by its long thick peduncles.

The type of A. trichocalyx (PH) was collected on the plains of the Arkansas by Nuttall and closely matches the description as published in the flora of North America (T. and G., 1838).

A. trichocalyx was long confused with A. mexicanus which, being the earlier name, took precedence in the literature. Recently (1956a) Barneby has satisfactorily demonstrated that A. mexicanus is in reality a variant of A. crassicarpus which is endemic to Texas (A. crassicarpus var. berlanderi). Thus, the combination A. trichocalyx becomes the earliest name available for this taxon.

Outside the north-central states the species extends through Arkansas, Oklahoma, and Texas. It grows in exposed or open areas and is common in some of the limestone regions of south-central Missouri. The flowering period extends from early April to late May.

Astragalus vexilliflexus Sheld. (Map 18. Plate XIV, Fig. A)

Astragalus vexilliflexus Sheld. Minn. Bot. Stud. 1:21. 1894.
*Astragalus pauciflorus Hook. Fl. Bor. Am. 1:149. 1834. non A. pauciflorus Pallas 1800.
Tragacantha pauciflora Kuntze Rev. Gen. 2:947. 1891.

Stems 10-44 mm long, several to many from a branching, woody caudex, decumbent to ascending, strigose with appressed simple hairs. Stipules 4-7 mm long, connate-clasping, ovate, strigose; the tips frequently spreading. Leaves 2-5 cm long, petiolate; leaflets 9-13, 7-14 mm long, narrowly elliptic to lance-elliptic or oblong, acute or obtuse, strigose below, sparsely strigose above, commonly folding on drying. Peduncles 1-5 cm long strigose, equalling or longer then the racemes. Bracts narrowly lanceolate, strigose, longer than the pedicels. Racemes 1-3 cm long, few- to several-flowered. Flowers 5-9 mm long, purple (occasionally whitish), the banner at right angles to the calyx tube. Calyx campanulate, strigose; tube 1.5-2.0 mm long, teeth 1.3-2.3 mm long, linear-subulate. Pods 6-11 mm, laterally compressed but not flat, 1-celled, sessile, strigose; both sutures prominent.

The specimens of A. vexilliflexus from our region vary greatly in size. Those collected in western North Dakota are frequently less than 20 cm long, but the specimens from South Dakota may exceed 35 cm. The larger plants tend to bear a greater number of flowers and fruits. The size differences appear to be largely due to the habitat, with the larger plants occurring on the better sites.

Since A. vexilliflexus is a substitute name typification must be based on A. pauciflorus Hooker. The writer has seen the type of this species; it agrees with the excellent description in the Flora Boreale-Americana (Hooker, 1834) and closely circumscribes the species herein treated as A. vexilliflexus.

The range of the species extends from Alberta southward to Idaho and Wyoming. In our areas the plants occur in the badlands of western North and South Dakota. The flowering period extends from June to mid-August

CARAGANA Lam.

Caragana Lam. Encyc. Meth. Bot. 1:615. 1783.
Robinia L. Sp. Pl. 722. 1753. pro parte.
Aspalathus Kuntze Rev. Gen. 161. 1891.

Small to large deciduous shrubs or small trees. Leaves even-pinnate; the rachis extended as a bristle or spine; leaflets 4-12 (in ours), oblanceolate, oblong or oval, entire. Stipules small and deciduous or persistent as spines. Flowers solitary, yellow. Calyx campanulate or turbinate; teeth well developed or nearly obsolete. Pods cylindric, linear-oblong, straight, glabrous, dehiscent.

This genus which contains some 50 to 60 species is native to southern Russia, Siberia, and China. Certain of the species have been widely cultivated in this country and elsewhere as ornamentals and hedge plants.

Caragana was monographed by Komarov (1908). The genus has been little studied in this country. Available herbarium material is scanty, and it has obviously not been possible to observe the various taxa in their native areas. Komarov's specific determinations, which from available data appear sound, have essentially been followed.

Key to the Species of Caragana

1. Shrubs 2-6 cm tall; leaflets 8-12. C. arborescens
1. Shrubs to 2 mm tall; leaflets 4.
   2. Plants armed with spiny stipules; leaflets linear-oblanceolate. C. aurantiaca
   2. Plant unarmed; leaflets oblanceolate. C. frutex

Caragana arborescens Lam. (Map 19. Plate XVI, Fig. A)

Caragana arborescens Lam. Encyc. 1:615. 1783.
Robinia caragana L. Sp. Pl. 722. 1753.
Caragana sibirica Medicus Verles Kurpfalz. Phys.-Oekon. Ges. 2:368. 1787. (fide Rehder, 1949).
Caragana inermis Moench Meth. Pl. 135. 1794. (fide Rehder, 1949).
Caragana caragana Karsten Deutsch Fl. 697. 1882. (fide Rehder, 1949).
Aspalathus caragana Kuntze Rev. Gen. 1:161. 1892.
Caragana arborescens var. typica Schneider Ill. Handb. Laubh. 2:95. 1907. (fide Rehder, 1949).

Shrubs to 6 m tall. Leaves 4-10 cm long, leaflets 8-12, 12-25 mm long, 5-15 mm wide, lance-oblong to elliptic or oval (in ours), cuspidate, villous above and below, becoming glabrate in age. Stipules narrow,

Plate XVI. Caragana arborescens, A. Section of stem with leaves and flowers. Caragana frutex, B. Section of stem with leaves and flowers. Caragana aurantiaca, C. Section of stem with leaves and flowers.

occasionally persisting as spines. Bracts reduced to rudiments at the juncture of the peduncle and the pedicel. Flowers 17-23 mm long, borne singly on peduncles 12-35 mm long, few to several from each bud. Pedicels 5-15 mm long. Calyx turbinate, pubescent; tube 4.5-7.5 mm long; teeth small or nearly obsolete, margin villous. Pod 35-55 mm long, straight, linear-oblong, glabrous, sessile; the valves coiling in dehiscence.

C. arborescens is cultivated throughout much of the north-central states where it serves a variety of purposes. It is used as a landscape shrub, hedge plant, or windbreak plant. The attractive yellow flowers which appear as the leaves develop make this plant a desirable ornamental. The soft, light-green foliage adds to the beauty of the plant, and its compact form and dense branching habit lead to its use as a hedge and windbreak. The species is hardy in cold and dry climates and as such it is well suited to the northwestern part of our range.

The binomial Caragana arborescens is a substitute name for Robinia caragana L., and as such must be typified by the latter name. Linnaeus' description of Robinia caragana is not complete enough to adequately typify the species, and one must rely upon the treatments of Komarov (1908) and Rehder (1949).

Komarov (1908) indicates that C. arborescens is native from central Siberia at 60° N. latitude to the Argun River in Mongolia. The blooming period extends from early May in the southern part of our range to mid-June in the northern part.

Both Kreuter (1930) and Tschechow (1930) have reported the somatic chromosome number of C. arborescens to be 16.

Caragana aurantiaca Koehne (Map 19. Plate XVI, Fig. C)

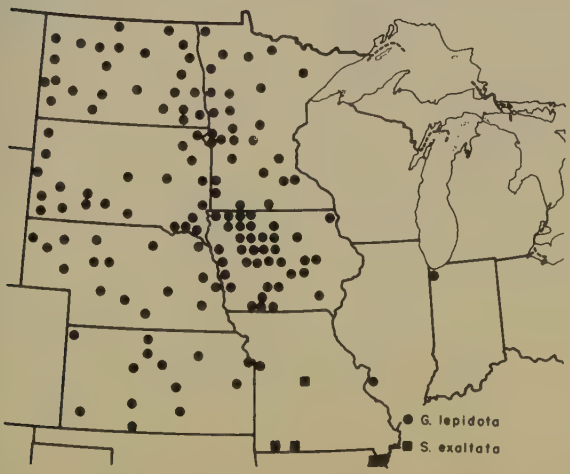
Caragana aurantiaca Koehne Dendrol. 340. 1893.
Caragana arenaria Dippel Handb. Laubh. 3:715. 1893.
non C. arenaria Loudon 1838. (fide Rehder, 1949).
Caragana pygmaea var. arenaria Maximowicz ex Komarov, Act. Hort. Petrop. 29:250. 1908. pro syn.

Shrubs to 1.2 m tall. Leaves 1-2 cm long, sessile to subsessile; leaflets 4, 5-15 mm long, 2-3 mm wide, linear-oblanceolate, acuminate-subulate, minutely puberulent below, glabrous above. Stipules 3-6 mm long, persistent as brownish spines. Peduncles 3-10 mm long. Pedicels 3-5 mm long. Bracts to 1 mm long at the juncture of the peduncle and pedicel. Flowers solitary, 15-22 mm long, yellow, an orange spot on the banner; wing auricles more than half as long as the claw. Calyx campanulate, glabrous; tube 3.5-4.5 mm long; teeth 1-2 mm long, triangular; the margin minutely pubescent. Pods 25-35 mm long, straight, sessile, glabrous.

Although unknown in the herbaria of our region this shrub is cultivated throughout much of North Dakota. In that region it is used as a landscape shrub and hedge plant. Its compact branching habit and spiny nature along with the attractive flowers render it a desirable ornamental.

C. aurantiaca is perhaps most closely related to C. pygmaea DC.

Map 19. Cultivated range of Caragana arborescens, C. aurantiaca, and C. frutex.



Map 20. Range of Glycyrrhiza lepidota and Sesbania exaltata.

from which it is distinguished by its flower color, more broadly campanulate calyces, and very long wing auricles.

According to Komarov (1908) the species is native to Turkey, Russia, and China and the adjacent regions of Altai. The plants flower in North Dakota during late May and June.

Caragana frutex (L.) Koch (Map 19. Plate XVI, Fig. B)

Caragana frutex (L.) Koch. Dendrol. 1:48. 1869.
Robinia frutex L. Sp. Pl. 723. 1753.
Robinia frutescens L. Sp. Pl. ed. 1044. 1762.
Caragana digitata Lam. Encyc. 1:616. 1783.
Caragana cuneata Moench Meth. Pl. 135. 1794. (fide Rehder, 1949).
Caragana frutescens (L.) DC. Prodr. 2:268. 1825.
Caragana frutescens var. α latifolia DC. Prodr. 2:268. 1825.
Caragana frutescens var. β angustifolia DC. Prodr. 2:268. 1825.
Caragana parvifolia Hoff. Preisverz. Pfl. ed 8. 39. 1836. (fide Rehder, 1949).
Aspalathus frutescens (L.) Kuntze Rev. Gen. 161. 1891.
Caragana frutescens var. grandiflora Rehder ex Bailey, Cycl. Am. Hort. 1:242. 1900.
Caragana frutex var. typica Schneider Ill. Handb. Laubh. 1:102. 1907. (fide Rehder, 1949).
Caragana frutex var. grandiflora Koehne ex Schneider Ill. Handb. Laubh. 2:103. 1907.
Caragana glomerata Halle ex Komarov, Act. Hort. Petrop. 29:226. 1908.
Caragana frutex var. macrantha Rehder Jour. Arnold Arb. 3:40. 1922.

Shrubs to 2 m tall. Leaves 2-3 cm long; leaflets 4, 10-20 mm long (in ours), 5-12 mm wide, oblanceolate, truncate or emarginate, cuspidate, villous above and below. Stipules adnate to the petiole, the free ends subulate. Bracts reduced to a collar at the juncture of the pedicel and peduncle. Flowers 18-28 mm long, borne singly on peduncles 5-20 mm long, few to several from each bud; pedicels 3-6 mm long. Calyx turbinate to short-cylindric, glabrous; tube 5.0-8.0 mm long; teeth 1-2 mm long, the nerves in each denture extended into a short spine, the margin minutely hairy. Pods 25-40 mm long, straight, linear-oblong, sessile, glabrous; the valves coiling upon dehiscence.

C. frutex does not appear to be as widely cultivated in the north-central states as C. arborescens. It is, however, an attractive spring-flowering shrub. C. frutex constitutes an important part of the landscape plantings on the campus of Iowa State University. The plants are hardy and occasionally produce some flowers in the autumn as well as in the spring.

Caragana frutex is typified by Robinia frutex L. Since the writer has not seen the type and the original description is not adequate to typify the species he has had to rely upon the treatments of Komarov (1908) and Rehder (1949).

Komarov (1908) has reported that C. frutex is native from eastern

Europe to the Ural Mountains and Siberia. The plants from our region flower in May and frequently again in September and early October.

Tschechow (1930) has reported the somatic chromosome number of C. frutex (as C. frutescens) to be 32.

GLYCYRRHIZA L.

Glycyrrhiza L. Sp. Pl. 741. 1753.
Liquiritia Nutt. Fraser Cat. 1813, nom. nud. (fide Nutt., 1818).

Plants herbaceous perennials. Leaves odd-pinnate stipulate; leaflets several to many, glandular punctate. Raceme several- to many-flowered; flowers yellowish or whitish. Calyx short-cylindric, glutinous; teeth lanceolate. Pods armed with uncinate appendages, indehiscent (in ours).

Glycyrrhiza is a widely distributed genus of about 15 species which occur in the Mediterranean region of Europe, subtropical Asia, Australia, extratropical South America and western North America. From G. glabra, an eastern European and western Asiatic species, is extracted the commercial licorice.

Only a single species is known from the United States. Its roots are evidently devoid of licorice properties and it is relegated to the position of a weedy species.

Glyccyrrhiza lepidota Pursh (Map 20. Plate XVIII, Fig. A)

Glycyrrhiza lepidota Pursh Fl. Am. Sept. 480. 1814.
Liquiritia lepidota Nutt. Fraser Cat. 1813. nom. nud. (fide Nutt., 1818).
Glycyrrhiza glutinosa Nutt. ex T. and G., Fl. N. Am. 1:298. 1838.
Glycyrrhiza lepidota var. glutinosa (Nutt.) S. Wats. Bot. Cal. 1:144. 1876.

Stems 35-85 cm long, ascending to erect, few to several from creeping rootstocks, pubescent throughout, the younger parts glandular punctate. Stipules 3-9 mm long, lanceolate, sparsely pubescent. Leaves 8-17 cm long; leaflets 15-19, 20-45 mm long, 5-17 mm wide, lanceolate, acute, glandular punctate on both surfaces, pubescent along the veins on the lower surface. Peduncles 3-7 cm long, sparsely villous and glandular throughout. Bracts lanceolate, scarious, glandular punctate and pubescent on the dorsal surface, exceeding half the length of the calyx. Racemes 3-8 cm long, many-flowered, dense. Flowers 3-12 mm long, yellowish. Calyx short-cylindric, glandular pubescent; tube 3-4 mm long; teeth 2.0-3.5 mm long, lanceolate. Pods 15-18 mm long, sessile, covered with uncinate appendages.

The species has been treated by various authors as consisting of an eastern variety with merely glandular punctate leaves and stems and a western variety with glandular-villous stems. The western form has been called variety glutinosa. All except a small number of our plants appear to belong to the eastern form of the species. There is a great

deal of variation in the degree of glutinosity from plants which are almost glandless to those in which the glands are very dense.

Beyond our region the species extends north into Saskatchewan and Alberta then southward to California and Texas. The plants grow on moist lake shores, in pasture land, along riverbanks, and in prairies. The blooming period extends from mid-June to early September.

The somatic chromosome number of G. lepidota is reported by Ledingham (1957) to be 16.

HALIMODENDRON Fischer

Halimodendron Fischer ex DC., Prodr. 2:269. 1825.
Robinia Pall. Reise Prov. Russ. Reich. 2:741. 1773. pro parte.
Pseudoacacia sensu Moench, Meth. 146. 1794. pro parte.

Shrubs to 2 m tall. Leaves even-pinnate; leaflets 4, entire, stipulate. Inflorescence 1- to 3-flowered. Flowers pink-purple. Stamens diadelphous. Calyx turbinate; teeth broadly triangular. Pods stipitate, inflated, dehiscent.

Halimodendron is a monotypic genus which appears to be closely related to the genus Caragana. The plants are native to the region extending from the Caucasus to the Altai. The species has been widely cultivated in Europe but evidently to a much lesser extent in this country.

Halimodendron halodendron (Pall.) Schneider (Plate XVII, Fig. D)

Halimodendron halodendron (Pall.) Schneider Ill. Handb. Laubh. 293, fig. 58. 1907.
Robinia halodendron Pall. Reise Prov. Russ. Reich. 2:741. tab. 2. 1773.
Caragana argentea Lam. Encyc. 1:616. 1783.
Pseudoacacia halodendron (Pall.) Moench Meth. 146. 1794.
Caragana halodendrum Hoff. Verzeich. Pfl. 46. 1824. (fide Rehder, 1949).
Halimodendron argenteum (Lam.) Fisch. in DC., Prodr. 2:269. 1825.
Halimodendron argenteum var. α vulgare Fisch. ex DC., Prodr. 2:269. 1825.
Halimodendron argenteum var. β subvirescens Fisch. ex DC., Prodr. 2:269. 1825.
Halimodendron subvirescens (Fisch.) G. Don Gen. Syst. 2:244. 1832.
Halimodendron emarginatum Jaubert and Spach Ann. Sci. Nat. Bot. II. 18:240. 1842. (fide Rehder, 1949).
Halimodendron cuspidatum Jaubert and Spach Ann. Sci. Nat. Bot. II. 18:239. 1842. (fide Rehder, 1949).
Halimodendron speciosum Carr. Rev. Hort. 1876:30. 1876. (fide Rehder, 1949).
Halimodendron halodendron Voss Vilmor. Blumengart. 1:215. 1894. pro syn. (fide Rehder, 1949).
Halimodendron halodendron forma purpureum Schneider Ill. Handb. Laubh. 293. 1907.

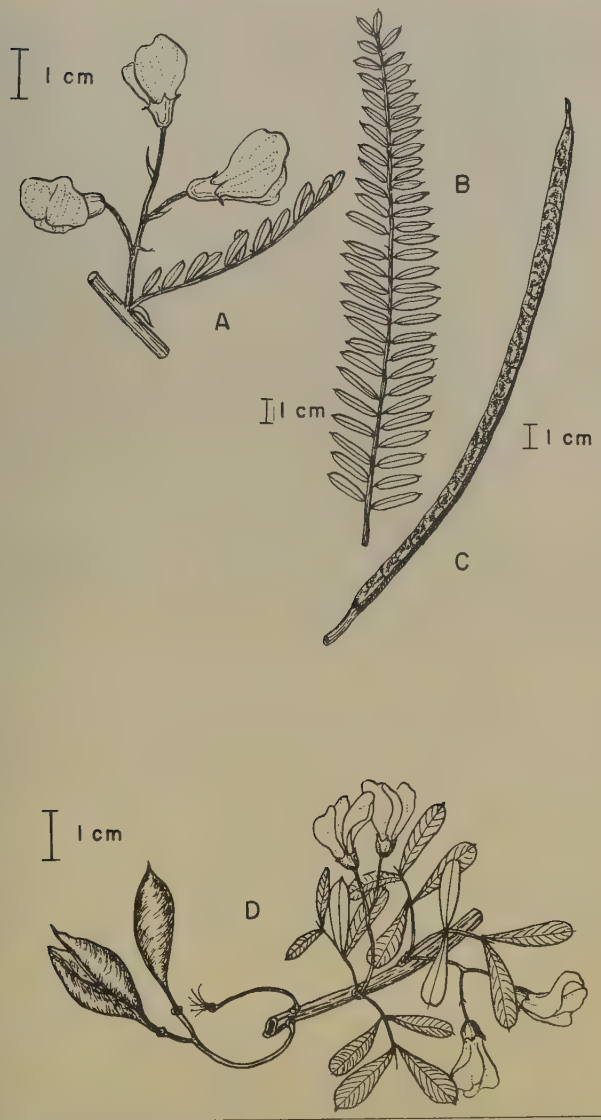


Plate XVII. Sesbania exaltata. A. Inflorescence and subtending leaf. B. Leaf. C. Fruit. Halimodendron halodendron, D. Section of stem with leaves, flowers and last year's fruit.

Shrubs to 2 m tall. Leaves 2-4 cm long, even-pinnate; the rachis produced at a spine and sometimes persistent at a thorn; leaflets 4, 5-20 mm long, 2-8 mm wide, distant, oblanceolate, cuspidate, minutely puberulent above and below. Stipules short, persistent as spines. Peduncles 10-25 mm long. Bracts to 1 mm long. Inflorescence 1- to 3-flowered; flowers 13-17 mm long, pink-purple. Calyx turbinate; tube 3-4 mm long; teeth to 1 mm long, broadly triangular, the margin pubescent. Pods 20-25 mm long, inflated, obovoid, glabrous, dehiscent; stipe 2-5 mm long.

H. halodendron is presently known from only two locations in the north-central states, cultivated on college grounds at Iowa State University and North Dakota State College. The Fargo, North Dakota plant is a robust shrub spreading by means of rhizomes. It flowers profusely and produces numerous pods which persist throughout the winter. The Iowa State University plants are in a poor state of vigor and have not flowered for several years.

This species seems to have possibilities as a spring-flowering ornamental and might be expected to do well in some of the more arid and saline parts of our region.

OXYTROPIS DC.

Oxytropis DC. Astragal. 24, 66. 1802. nom cons. (homonymum prius Spiesia Neck.)
Argallus Neck. Elem. 3:12. 1790.
Spiesia Neck. Elem. 3:13. 1790.
Astragalus L. Sp. Pl. 755. 1753. pro parte.

Herbaceous perennial plants, mostly acaulescent. Leaves alternate, odd-pinnate. Stipules connate-clasping, adnate to the petiole, ovate to lanceolate or triangular. Inflorescence a scapose raceme. Bracts lanceolate to ovate. Flowers few to many, purplish, yellowish, or whitish; the keel-tip produced into a beak, maculate or immaculate. Calyx tube cylindric or campanulate, 5-toothed. Pods sessile or substipitate (in ours), straight, erect (reflexed in O. deflexa), papery, leathery, or woody, 2-celled or partly so by the intrusion of the ventral (upper) suture.

The genus Oxytropis, with its circumboreal distribution, is best represented in Europe and Asia. Of the possibly 200 species in this genus only 22 are known for North America and only one-third of those occur within the north-central states.

Validity of the Genus

Oxytropis is defined on the basis of flower structure, pod characteristics, and habit. No single character is infallible in the separation of Oxytropis from the closely related genus Astragalus, and certain authors (e.g. Tidestrom, 1937 and Shinners, 1958) have combined the two genera. On this point the writer agrees with Barneby (1952). Until it can be shown that the gap between the two genera is no greater than that existing between sections within Astragalus, that there are species referable with equal justice to either genus, or that Oxytropis is polyphyletic, the

submergence of Oxytropis in the older genus will do nothing to clarify relationships. Indeed, a union of the two genera is not only impractical but patently unrealistic in the phylogenetic sense.

It is this author's (possibly somewhat subjective) opinion that Oxytropis represents a unified phyletic group, related to, but definitely apart from, the sprawling Astragalus assemblage. Such overlap of characters as appears to exist seems due to somewhat parallel evolutionary tendencies and not to inter-reticulation of the constituent complexes.

In the species from our region there is no major problem in the separation of the members of the two genera. The beaked-keel is prominent in all of our species of Oxytropis and is not present in any of the Astragali. In all except one species of Oxytropis in the north-central states the pods are erect, and in all of them the pods are partly or completely 2-celled by the intrusion of the ventral (upper) suture. Only a few north-central states Astragali bear erect, 2-celled pods; in these, the dorsal (lower) suture is intruded. The caespitose, acaulescent habit of Oxytropis is common to all of our species except O. deflexa.

Relationships

On morphological bases the species of Oxytropis present in the north-central states can be divided into three phylogenetic lines. O. deflexa, with the caulescent habit and reflexed pods, and O. splendens, with its fastigate leaflets, do not appear to be closely related to the other members in our region. The remaining species are morphologically much alike and possibly represent an irregular natural unit. However, O. multiceps with its inflated calyces is perhaps less closely related to the other members (O. lambertii, O. sericea, O. campestris, O. viscida).

Cytology

The basic chromosome number of the genus appears to be 8; cytological studies indicate that the genus contains a series of polyploids. The chromosome number is known for five of our species; two are diploids, one is a tetraploid, and two are hexaploids.

Key to the Species of Oxytropis

1. Plants usually caulescent; stipules only slightly adnate to the petioles: pods pendulous. O. deflexa
1. Plants scapose or subscapose, stipules adnate to the petioles; pods erect or spreading.
   2. Inflorescence and pod glandular-viscid. O. viscida
   2. Inflorescence and pod variously pubescent, but not glandular-viscid.
      3. Leaves with verticillate leaflets. O. splendens
      3. Leaves with leaflets opposite or scattered, but not verticillate.
         4. Pubescence of malpighian hairs; the flowers usually pink-purple. O. lambertii
         4. Pubescence basifixed; flowers purplish, yellowish, or whitish.

5. Racemes 1- to 5-flowered, subcapitate; calyx expanding in fruit. O. multiceps
5. Racemes 6- to many-flowered, subcapitate to elongate; calyx not expanding in fruit.
   6. Corolla purplish, pinkish, or bluish (plants from North Dakota, Minnesota, or Wisconsin). O. campestris
   6. Corolla whitish or yellowish, rarely purplish (plants from the Black Hills and western Nebraska).
      7. Flowers mostly 12-15 mm long, yellowish; the keel usually immaculate; foliage green. O. campestris
      7. Flowers mostly 18-25 mm long, whitish (rarely purplish); the keel-tip usually maculate; foliage sericeous. O. sericea

Oxytropis campestris (L.) DC. (Map 21. Plate XVIII, Fig. B)

Oxytropis campestris (L.) DC. Astragal. 74. 1802. (fide Barneby, 1952).
Astragalus campestris L. Sp. Pl. 761. 1753.
Oxytropis campestris β Hook. Fl. Bor. Am. 1:147. 1834.
*Oxytropis monticola A. Gray Proc. Am. Acad. 20:6. 1884.
Spiesia monticola (A. Gray) Kuntze Rev. Gen. 207. 1891.
Aragallus monticola (A. Gray) Greene Pittonia 3:212. 1897.
*Aragallus gracilis A. Nels. Erythea 7:60. 1899.
*Aragallus dispar A. Nels. Erythea 7:61. 1899.
Aragallus villosus Rydb. Bull. Torrey Club 28:36. 1901.
Oxytropis dispar (A. Nels.) K. Schum. Just's Jahresb. 27:496. 1901.
Oxytropis gracilis (A. Nels.) K. Schum. Just's Jahresb. 27:496. 1901.
Oxytropis villosus (Rudb.) K. Schum. Just's Jahresb. 29:543. 1903.
Aragallus albertinus Greene Proc. Biol. Soc. Wash. 18:15. 1905.
Aragallus macounii Greene Proc. Biol. Soc. Wash. 18:16. 1905. pro parte.
Aragallus cervinus Greene Proc. Biol. Soc. Wash. 18:16. 1905.
*Aragallus luteolus Greene Proc. Biol. Soc. Wash. 18:17. 1905.
Oxytropis luteola (Greene) Piper and Beattie Fl. N.W. Coast 227. 1915.
Oxytropis luteola (Greene) A. Nels. Univ. Wyo. Pub. Sci. 1:117. 1926.
*Oxytropis okanoganea St. John Proc. Biol. Soc. Wash. 41:102. 1928.
*Oxytropis olympica St. John Proc. Biol. Soc. Wash. 41:103. 1928.
*Oxytropis cascadensis St. John Proc. Biol. Soc. Wash. 41:105. 1928.
Oxytropis albertina (Greene) Rydb. Fl. Prair. and Pl. 484. 1932.
*Oxytropis chartacea Fassett Rhodora 38:95. 1936.
Astragalus albertinus (Greene) Tidestr. Proc. Biol. Soc. Wash. 50:19. 1937.
Astragalus rydbergianus Tidestr. Proc. Biol. Soc. Wash. 50:19. 1937.
Astragalus mazama (St. John) G.N. Jones Univ. Wash. Publ. Bot. 7:175. 1938.
Astragalus grayanus Tidestr. ex Tidestr. and Kitt., Fl. Ariz. and N. Mex. 216. 1941.
Oxytropis campestris var. dispar (A. Nels.) Barneby Leafl. West. Bot. 4:111. 1951.

Plate XVIII. Glycyrrhiza lepidota, A. Inflorescence and leaf.
Oxytropis campestris, B. Plant with inflorescence.

Oxytropis campestris var. gracilis (A. Nels.) Barneby Leafl. West. Bot. 4:111. 1951.
Oxytropis campestris var. chartacea (Fassett) Barneby Proc. Cal. Acad. Sci. IV. 27:269. 1952.

Plants caespitose, acaulescent, from a branching caudex. Leaves 7-20 cm; leaflets 13-33, 11-26 mm long, 2-5 mm wide, lance-elliptic to linear oblong; opposite or distant, pilose above and below with simple hairs, green. Stipules ovate to lanceolate, acuminate, connate, adnate to the petioles, villous, ciliate. Scape 8-20 cm, villous. Raceme 3-9 cm, lax. Bracts linear-lanceolate, herbaceous, longer than the calyx. Flowers 12-17 mm long, yellow, pink-purple, or polychrome. Calyx cylindric, villous with dark and light hairs; tube 6.0-6.5 mm; teeth 2.5-3.5 mm, triangular. Pods sessile, 8-15 mm long, extended into a beak, erect, pilose, partially 2-celled by intrusion of the upper (ventral) suture.

This widely distributed (Eurasia and North America) complex is represented, according to Barneby's (1952) interpretations, by three varieties in the north-central states out of a total of eight in North America. The writer has attempted to critically evaluate the varieties present in our region and has found Barneby's treatment to be reasonably adequate. However, much work still remains to be done concerning the interrelationships of the varieties and the details of their distribution.

The relationships of O. campestris to the other species of Oxytropis in the north-central states are uncertain. There are intermediate forms between O. campestris var. gracilis and O. sericea. These are (perhaps in arbitrary fashion) usually referable to one species or another. The cytology of such populations should prove interesting because the somatic chromosome number of O. campestris var. gracilis is reported as 32 and that of O. sericea (var. spicatus) is said to be 48 (Ledingham, 1957). Barneby (1952) has suggested that O. campestris var. dispar arose as a fertile hybrid between O. lambertii and O. campestris var. gracilis. The cytological nature of variety dispar is unknown, but the somatic chromosome number of O. lambertii has been reported by Ledingham (1957) as 48. O. viscida appears to be closely related to O. campestris, and indeed it may represent an evolutionary line from some basic O. campestris type.

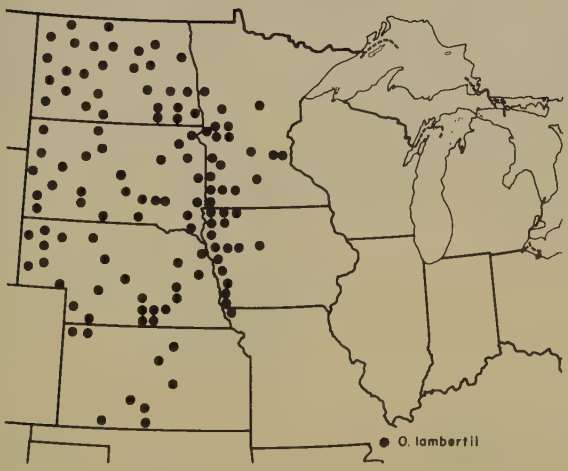
The writer has not seen the type of O. campestris and the original description is not adequate to typify this species. Therefore, the treatment by Barneby (1952) has been followed. The list of synonyms presented above include only those names belonging to that portion of the complex present in our region.

The O. campestris complex is circumboreal in the arctic and temperate regions of the world. The plants grow in prairies, meadows, and open woodlands in moist or dry soils. The blooming period extends from late May to mid-July.

Oxytropis deflexa (Pall.) DC. (Map 21. Plate XIX, Figs. A-C)

Oxytropis deflexa (Pall.) DC. Astragal. 33 tab. 27. 1802.
Astragalus deflexus Pall. Act. Acad. Petrop. 2:268. tab. XV. 1783.

Map 21. Range of Oxytropis campestris and O. deflexa.



Map 22. Range of Oxytropis lambertii.

Aragallus deflexus (Pall.) A. Hell. Cat. N. Am. Pl. 4. 1898.
Oxytropis deflexa var. β sericea T. and G. Fl. N. Am. 1:342. 1838.
*Oxytropis retrorsa Fern. Rhodora 30:140. 1928.
Oxytropis retrorsa var. sericea (T. and G.) Fern. Rhodora 30:140. 1928.
Oxytropis deflexa var. culminis Jeps. Fl. Cal. 2:381. 1936.

Plants 10-40 cm tall, caespitose, caulescent (rarely acaulescent); stems long villous with simple hairs, decumbent to ascending, few to several from a caudex. Leaves 5-20 cm long; leaflets 23-39, 7-20 mm long, 2-8 mm wide, narrowly lanceolate, rounded at the base, villous with fine, simple hairs. Stipules 7-20 mm long, connate around the stems, slightly adnate to the petiole, the free ends lanceolate, villous dorsally. Peduncles 12-26 cm long, villous. Bracts lanceolate, shorter than the calyx tube, villous. Racemes 3-14 cm long, much elongating in fruit, many-flowered. Flowers 6-9 mm long, whitish, pinkish, or bluish. Calyx campanulate, villous; tube 2.5-3.5 mm long; teeth 2.5-4.0 mm long, narrowly lanceolate. Pods 8-18 mm long, spreading or reflexed, narrowly oblong, straight or curved, sulcate on the ventral suture, strigulose.

The members of this species in the north-central states represent only a small part of an enormous complex which occurs from the Altai Mountains of western Mongolia eastward through Siberia to Alaska and then southward along the Rocky Mountains to California and New Mexico. Other parts of the complex extend eastward across Canada to Newfoundland and a relict is also present in arctic Norway (Barneby, 1952).

The figure of Astragalus deflexus Pallas (tab. XV) in the Acta Academiae Scientiarum Imperialis Petropolitanae is clearly that of this species.

According to Barneby (1952) the portion of the complex represented by the material from our region belongs to O. deflexa var. sericea. The evaluation of this variety and its position in relation to the total deflexa complex is beyond the scope of the present paper. However, in order to limit the number of synonyms the list was restricted to those names involved with variety sericea.

The plants grow in wooded areas, along streams, and on lake shores. The flowering occurs during July and August.

The somatic chromosome number of O. deflexa is reported to be 16 (Ledingham, 1957).

Oxytropis lambertii Pursh (Map 22. Plate XX, Figs. A,B)

Oxytropis lambertii Pursh Fl. Am. Sept. 2:740. 1814. (*fide Barneby, 1952).
Astragalus lambertii (Pursh) Spreng. Syst. 3:308. 1826.
Oxytropis lambertii γ T. and G. Fl. N. Am. 1:339. 1838.
Oxytropis hookeriana Nutt. ex T. and G., Fl. N. Am. 1:340. 1838.
Oxytropis plattensis Nutt. ex T. and G., Fl. N. Am. 1:340. 1838.
Spiesia lambertii (Pursh) Kuntze Rev. Gen. 207. 1891.
Aragallus lambertii (Pursh) Greene Pittonia 3:212. 1897.

Plate XIX. Oxytropis deflexa, A. Plant. B. Flowering raceme. C. Fruiting raceme.

*Aragallus involutus A. Nels. Erythea 7:64. 1899.
Oxytropis involuta (A. Nels.) K. Schum. Just's Jahresb. 27:496. 1901.
*Oxytropis bushii Gand. Bull. Soc. Bot. Fr. 48:xvii. 1901.
Oxytropis lambertii forma mixta Gand. Bull. Soc. Bot. Fr. 48:xvii. 1901.
* Aragallus falcatus Greene Proc. Biol. Soc. Wash. 18:13. 1905.
*Aragallus rigens Greene Proc. Biol. Soc. Wash. 18:14. 1905.
*Aragallus formosus Greene Proc. Biol. Soc. Wash. 18:14. 1905.
*Aragallus angustatus Rydb. Bull. Torrey Club 34:422. 1907.
*Aragallus aven-nelsonii Lunell Bull. Leeds Herb. 2:6. 1908.
Oxytropis angustata (Rydb.) A. Nels. Univ. Wyo. Pub. Sci. 1:116. 1926.
Oxytropis aven-nelsonii (Lunell) A. Nels. Univ. Wyo. Pub. Sci. 1:116. 1926.
Oxytropis falcata (Greene) A. Nels. Univ. Wyo. Pub. Sci. 1:118. 1926.

Plants 10-50 cm tall, caespitose, acaulescent, arising from a branching caudex. Leaves 8-23 cm long; leaflets 7-19, 5-40 mm long, 2-6 mm wide, narrowly lanceolate, elliptic, or linear, opposite or scattered, strigose to pilose above and below with malpighian hairs. Stipules persistent, pilose to glabrate dorsally, adnate to the petiole. Scape 6-30 cm long. Bracts lanceolate, pilose dorsally, shorter or longer than the calyx tube. Racemes 4-10 cm long, at first dense, becoming lax in age, 6- to 18-flowered. Flowers 12-25 mm long, pink-purple (rarely white). Calyx cylindric, strigulose; tube 5.0-9.0 mm; teeth 1.5-4.0 mm, narrowly triangular. Pods 8-15 mm long, sessile, oblong to ovoid, extending into a beak, erect, villous, 2-celled or nearly so by the intrusion of the ventral (upper) suture.

O. lambertii is our most widespread species of Oxytropis. It occurs in a number of habitats and is highly variable. An indication of the variability of this complex is found in the number of synonyms which have arisen as the result of the description of minor variants as distinct species. At least a part of the variation is the result of phenotypic expression which is conditioned by the type of habitat in which the plants grow. The plants from better sites often grow to 40 cm in height (including the scapose raceme) and the leaflets are long, broad and thin in texture. However, plants from poor habitats such as overgrazed pastures, or from dry regions where competition is keen, may not exceed 10 cm in height and the leaflets are frequently very small and thick in texture.

The plants also vary in the degree of pubescence, leaflet shape, pod shape and length, and in flower size. Aragallus aven-nelsonii Lunell (isotype, MIN) is a low-growing form of O. lambertii in which the leaflets are narrow and few in number. A. angustatus Rydberg (isotype, MIN) is a depauperate form similar to A. aven-nelsonii. Oxytropis bushii Gandoger and O. falcatus Greene were both based on parts of the same collection. An isotype of those two species (MIN) demonstrates the plant involved to be a part of the O. lambertii complex in which the leaflets are narrow, involute, and stiff. O. involutus A. Nelson likewise possesses

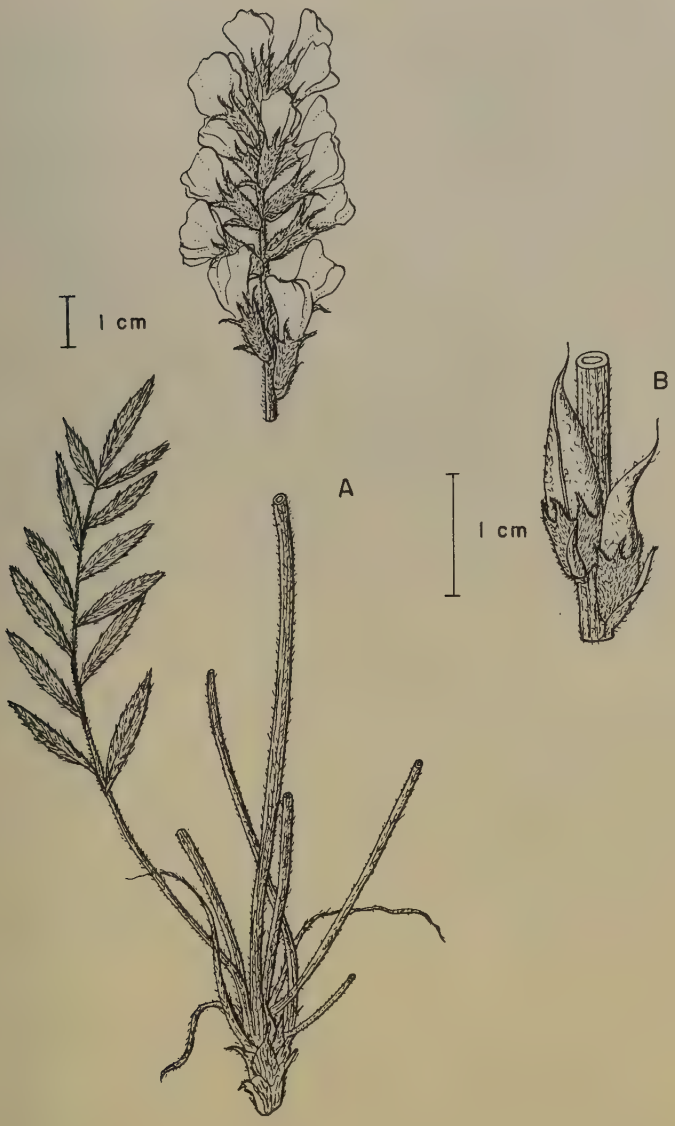


Plate XX. Oxytropis lambertii, A. Plant with inflorescence. B. Section of fruiting raceme.

involute leaflets (isotype, MIN). Aragallus formosus Greene was based on robust plants with broad leaflets and compact inflorescences (type, US). The type of A. rigens is a glabrate, narrow-leaved plant bearing mature pods. The pods are tipped by long attenuate beaks.

If all of the variants of this complex were similarly designated as distinct species the list of synonymy would be endless. Indeed, the plants observed by the writer in a single short-grass prairie pasture in Sioux County, Nebraska would easily constitute several species as described by Greene, Rydberg, and Nelson. The flowers of one plant did not exceed 12 mm in length and the leaflets are short and narrow. Other plants had flowers over 20 mm long, and long, broad leaflets. A population of robust, large-flowered plants was noted in Morrill County, Nebraska. The flowers were more than 20 mm in length and the calyces were densely villous.

Plants which appear to be hybrids between O. lambertii and O. sericea do occur. They commonly take on the flower color of O. lambertii, but have the pubescence characteristics of O. sericea.

Beyond our region the species extends from Manitoba and Saskatchewan south to southern Arizona and north-central Texas. The plants are highly ubiquitous. They occur in prairies, badlands, and in the mountains in open woodlands. They grow on all types of soils from seleniferous clays to gravels. The blooming period extends from early May in the southern part of the range to late July in the northern part.

Ledingham (1957) has reported the somatic chromosome number of O. lambertii to be 48.

*Oxytropis multiceps Nutt. (Map 23)

Oxytropis multiceps Nutt. ex T. and G., Fl. N. Am. 1:342. 1838.
Physocalyx multiceps Nutt. ex A. Gray, Proc. Am. Acad. 6:234. 1864. pro parte.
Oxytropis multiceps var. minor A. Gray Proc. Am. Acad. 20:2. 1884.
Spiesia multiceps (Nutt.) Kuntze Rev. Gen. 207. 1891.
Aragallus multiceps (Nutt.) A. Hell. Cat. N. Am. Pl. 4. 1898.
Aragallus minor (A. Gray) Ckll. ex Daniels, Univ. Mo. Stud. (Sci. ser.) 2:158. 1911.
Oxytropis minor (A. Gray) Ckll. Torreya 18:180. 1918.
Astragalus bisontum Tidestr. Proc. Biol. Soc. Wash. 50:18. 1937.
Astragalus bisontum var. minor (A. Gray) Tidestr. Proc. Biol. Soc. Wash. 50:18. 1937.

Plants 2-10 cm tall, caespitose, acaulescent, from a branching caudex. Leaves 1-5 cm long; leaflets 5-9, 5-13 mm long, lanceolate, oblanceolate, elliptic, or oblong, acute or rarely obtuse, silky-pilose or silvery. Stipules 4-14 mm long, lanceolate to ovate, membranous, ascending pilose, adnate to the petioles. Scapes 1.5-3.0 cm long, equalling or commonly shorter than the leaves, spreading or prostrate. Bracts herbaceous, ovate to lanceolate. Racemes 1- to 4-flowered. Flowers 17-24 mm long, pink-purple (drying bluish). Calyx swollen at anthesis, in fruit much inflated, densely villous; tube 5.5-10 mm; teeth 2.0-3.0 mm, triangular.

Map 23. Range of Oxytropis multiceps, O. sericea, O. splendens, and O. viscida.

Map 24. Cultivated range of Robinia hispida, R. neomexicana, and R. viscosa.

Pod 6-10 mm long, included in the calyx and falling with it, dorsally compressed and sulcate ventrally, partially 2-celled by the intrusion of the ventral suture, villous, chartaceous; stipe to 1.5 mm long.

This species is included in our flora on the basis of a single collection (Rydberg) from the Upper Lawrence Fork, Kimball County, Nebraska. Its status otherwise in the north-central states is unknown. It is possible that the entity is adventive, but it does occur in eastern Wyoming and Colorado not far removed from the Nebraska location.

Beyond our region O. multiceps occurs in southeastern Wyoming and northeastern Colorado. The plants flower during June. They grow on gravelly summits and bare ridges.

Oxytropis sericea Nutt. (Map 23. Plate XXI, Figs. A,B)

Oxytropis sericea Nutt. ex T. and G., Fl. N. Am. 1:339. 1838. (*fide Barneby, 1952).
Oxytropis lambertii var. sericea (Nutt.) Gray Proc. Am. Acad. 20:7. 1884.
Spiesia lambertii var. sericea (Nutt.) Rydb. Fl. Neb. 21:43. 1895.
*Oxytropis lambertii var. ochroleuca A. Nels. Bull. Wyo. Expt. Sta. 28:98. 1896.
Aragallus sericea (Nutt.) Greene Pittonia 3:212. 1897.
Aragallus lambertii var. sericea (Nutt.) A. Nels. Erythea 7:62. 1899.
*Aragallus albiflorus A. Nels. Erythea 7:62. 1899.
*Aragallus albiflorus var. condensatus A. Nels. Erythea 7:62. 1899.
Aragallus saximontanus A. Nels. Erythea 7:190. 1899.
*Aragallus pinetorum A. Heller Bull. Torrey Club 26:548. 1899.
Aragallus saximontanus var. condensatus (A. Nels.) A. Nels. Erythea 7:190. 1899.
Astragalus albiflorus (A. Nels.) Gand. Bull. Soc. Bot. Fr. 48:xiv. 1901.
Oxytropis albiflora (A. Nels.) E. Schum. Just's Jahresb. 27:496. 1901. non O. albiflora Bunge 1874.
Oxytropis pinetorum (A. Heller) K. Schum. Just's Jahresb. 27:496. 1901.
Aragallus pinetorum var. veganus Ckll. Torreya 2:155. 1902.
*Aragallus majusculus Greene Proc. Biol. Soc. Wash. 18:12. 1905.
*Aragallus aboriginum Greene Proc. Biol. Soc. Wash. 18:13. 1905.
*Aragallus invenustus Greene Proc. Biol. Soc. Wash. 18:14. 1905.
Aragallus veganus (Ckll.) Woot. and Standl. Contr. U.S. Nat. Herb. 16:136. 1913.
Oxytropis vegana (Ckll.) Woot. and Standl. Contr. U.S. Nat. Herb. 19:371. 1915.
Oxytropis saximontana (A. Nels.) A. Nels. Univ. Wyo. Pub. Sci. 1:113. 1926.
Oxytropis condensata (A. Nels.) A. Nels. Univ. Wyo. Pub. Sci. 1:115. 1926.
Astragalus albiflorus (A. Nels.) Tidestr. Proc. Biol. Soc. Wash. 50:19. 1937.

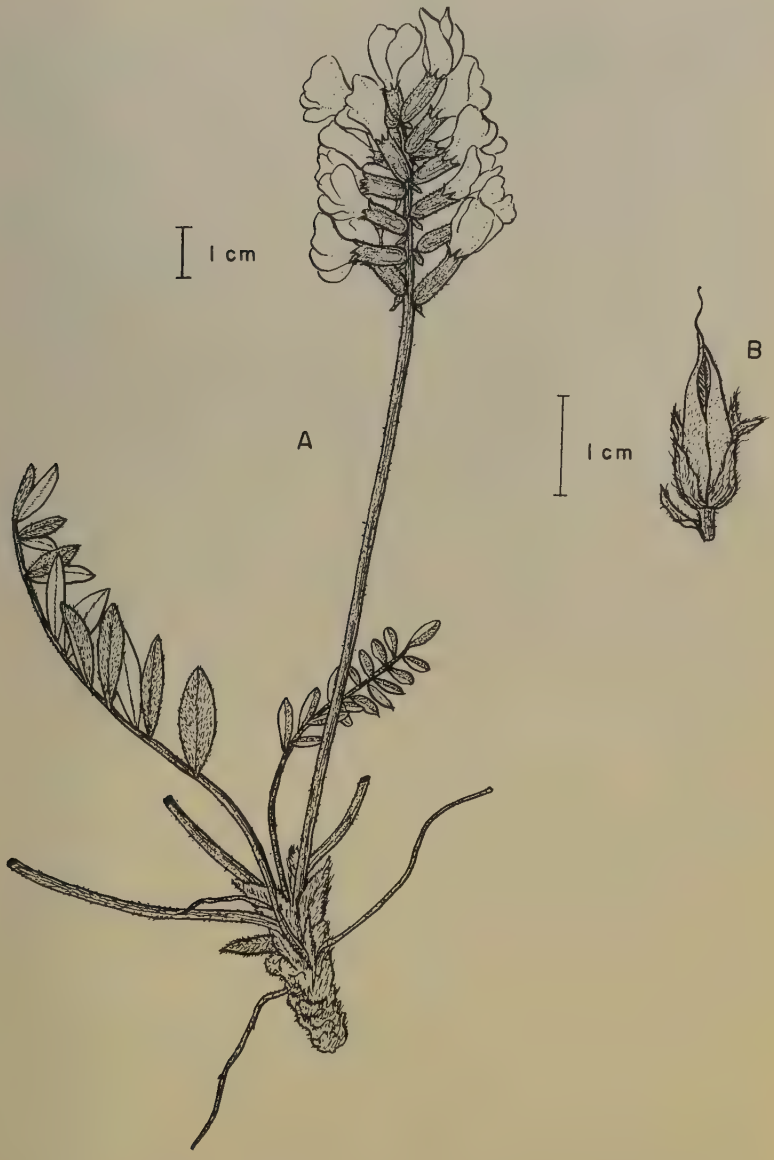


Plate XXI. Oxytropis sericea, A. Plant with inflorescence. B. Fruit.

Astragalus saximontanus (A. Nels.) Tidestr. ex Tidestr. and Kitt., Fl. Ariz. and N. Mex., 216. 1941.

Plants 15-50 cm tall, caespitose, acaulescent, from a branching caudex. Leaves 3.5-30 cm long; leaflets 11-25, 10-40 mm long, 4-9 mm wide, pilose to sericeous above and below with simple pubescence, ovate to elliptic or lanceolate. Stipules adnate to the petioles, villous to glabrate dorsally, ciliate, connate. Scapes 11-27 cm long. Bracts narrowly lanceolate, shorter than or equalling the calyx tube, villous dorsally, herbaceous. Racemes 6- to 27-flowered, commonly elongating in fruit. Flowers 15-25 mm long, whitish or yellowish; the keel purple-tipped. Calyx cylindric, villous with dark and light hairs; tube 7.5-9.5 mm; teeth 2.0-3.5 mm, villous with black and white hairs. Pods 10-25 mm long, erect, sessile, oblong to ovoid, coriaceous, or nearly woody, rigid, densely strigulose, 2-celled or nearly so by the intrusion of the ventral (upper) suture.

O. sericea as herein interpreted exhibits a wide degree of variation in flower color, stature, leaflet shape and texture, and in the degree to which the vesture is sericeous. The flowers are commonly white or light yellow with purple-tipped keels, but specimens from Nebraska may bear purple flowers. The leaflets are usually thick in texture and densely sericeous. However, plants bearing thin leaflets which are green in color are common. This latter group of plants seem to inhabit more mesophytic situations, such as open woods and north-facing slopes. Those plants with thick, densely sericeous leaves tend to occur in more exposed, xeric situations.

Many earlier workers treated O. sericea as an element of the O. lambertii complex. There are, however, several consistent distinctions, among them the woody pods and finer, basifixed hairs of the latter species.

Over much of the range of O. sericea the whitish flowers with purple-tipped keels can be used as a distinguishing feature. However, where O. sericea is contiguous with O. campestris there is a series of intermediates which tend to lack the purple-tipped keels, and frequently, where O. sericea grows in close contact with O. lambertii, there is a series of intermediates which have purple flowers.

Many of the variants of O. sericea have been described as either distinct species or varieties. O. lambertii var. ochroleuca is based on a form of O. sericea with whitish flowers (type, RM). The variety condensatus is a dwarf form of the species in which the racemes and scapes are much contracted (type, RM). Aragallus invenustus (type, US) is similar to Nelson's variety ochroleuca. Aragallus majusculus (type, US), A. aboriginum (type, US), and A. pinetorum (type, US) are all based on extremely robust specimens of O. sericea.

The writer has not seen the type of O. sericea and has based the typification of the species on the interpretation of Barneby (1952) who cites the type specimen from the New York Botanical Garden.

In order to limit the number of synonyms listed in the present paper the writer has included only those which are involved with O. sericea var. sericea as per Barneby's treatment.

The species extends from Manitoba and British Columbia south to

Utah and New Mexico. The plants grow in plains, prairies, and foothill areas in our region. They flower during May and June.

The somatic chromosome number of O. sericea has been reported by Ledingham (1957) to be 48 (in var. spicata).

Oxytropis splendens Dougl. (Map 23. Plate XXII, Fig. A)

Oxytropis splendens Dougl. ex Hook., Fl. Bor. Am. 1:147. 1834.
Oxytropis oxyphylla sensu Richards. ex Frankl. Jour. Bot. Append. 745. 1823.
Oxytropis splendens α vestita Hook. Fl. Bor. Am. 1:148. 1834.
Oxytropis splendens β richardsoni Hook. Fl. Bor. Am. 1:148. 1834.
Spiesia splendens (Dougl.) Kuntze Rev. Gen. 207. 1891.
Aragallus splendens (Dougl.) Greene Pittonia 3:211. 1897.
Aragallus caudatus Greene Pittonia 4:69. 1899.
Oxytropis caudatus (Greene) K. Schum. Just's Jahresb. 27:496. 1901.
Oxytropis richardsonii (Hook.) K. Schum. Just's Jahresb. 27:496. 1901.
Oxytropis splendens forma nelsonii Gand. Bull. Soc. Bot. Fr. 48: xvii. 1901.
Oxytropis splendens forma strigosa Gand. Bull. Soc. Bot. Fr. 48: xvii. 1901.
Aragallus galegicides Greene Proc. Biol. Soc. Wash. 18:16. 1905.
Oxytropis richardsonii (Hook.) Woot. and Standl. Contr. U.S. Nat. Herb. 19:370. 1915.
Astragalus splendens (Dougl.) Tidestr. Proc. Biol. Soc. Wash. 50:18. 1937.
Astragalus splendens var. richardsonii (Hook.) Tidestr. Proc. Biol. Soc. Wash. 50:18. 1937.

Plants 10-35 cm tall, caespitose, acaulescent; stems from a branching woody caudex. Leaves 7-29 cm long; leaflets verticillate on the rachis in 7-15 fascicles (40-70 leaflets); 5-25 mm long, 2-6 mm wide, narrowly lanceolate, rounded at the base. villous throughout; petioles and rachis shaggy villous. Stipules membranous, long pilose dorsally, the free ends triangular to acuminate, adnate to the petioles. Peduncles 9-29 cm long, long-villous. Bracts narrowly lanceolate, shorter than or equalling the calyx, villous dorsally. Racemes 3-10 cm long, little elongating in fruit, many-flowered. Flowers 12-15 mm long, pinkish or bluish. Calyx cylindric, long-villous; tube 5.0-6.0 mm long; teeth 2.0-4.0 mm long. Pods 10-17 mm, ovoid to oblong, sulcate on both sutures, chartaceous, villous; beak 3-4 mm long.

O. splendens is a widespread species of the Rocky Mountains and the northern part of North America. Indeed this taxon possibly represents an extension of an old-world complex of related plants which are morphologically similar in having verticillate leaflets. The specimens from our region represent the southern extension of the species in the plains.

O. splendens is well marked by its compact, cylindric raceme of

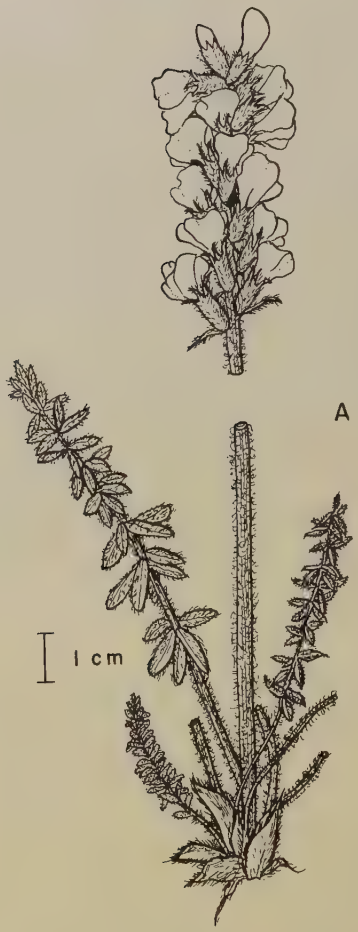


Plate XXII. Oxytropis splendens, A. Plant with inflorescence.

small purplish flowers, whorled leaflets, and fine silky-villous pubescence. It is a rather stable species. The plants vary mainly in two ways; the length of the bracts and the degree of pubescence. Most of the proposed segregates have been based on various combinations of these two characters.

The writer has not seen the type of O. splendens, but several Douglas specimens have been examined (OXF). This material is congruent with the original description, and falls within the limits of the taxon as understood in our region.

Beyond our region the plants extend from Ontario to Alaska and south through the mountains to New Mexico. They occur in upland situations in prairies and along river banks. The blooming period extends from late June to late July.

The somatic chromosome number of O. splendens has been reported to be 16 (Ledingham, 1958).

Oxytropis viscida Nutt. (Map 23)

Oxytropis viscida Nutt. ex T. and G., Fl. N. Am. 1:341. 1838. (*fide Barneby, 1952).
Oxytropis mollis Nutt. ex A. Gray, Proc. Am. Acad. 6:235. 1864. pro syn.
Oxytropis campestris var. viscida (Nutt.) Wats. Bot. King Expl. 77. 1871.
Spiesia viscida (Nutt.) Kuntze Rev. Gen. 207. 1891.
Aragallus viscidus (Nutt.) Greene Pittonia 3:211. 1897.
Aragallus viscidulus Rydb. Mem. N.Y. Bot. Gar. 1:523. 1900.
Aragallus viscidulus var. depressus Rydb. Mem. N.Y. Bot. Gard. 1:523. 1900.
Oxytropis viscidula (Rydb.) Tidestr. Contr. U.S. Nat. Herb. 25:332. 1925.
Oxytropis gaspensis Fern. and Kels. Rhodora 30:123. 1928.
Astragalus gaspensis (Fern. and Kels.) Tidest. Proc. Biol. Soc. Wash. 50:19. 1937.
Astragalus viscidus (Nutt.) Tidestr. Proc. Biol. Soc. Wash. 50:19. 1937.
*Oxytropis ixodes Butters and Abbe Rhodora 45:2. 1943.

Plants caespitose, acaulescent, from a branching caudex. Leaves 8-16 cm long; leaflets 31-51, 7-17 mm long, 2-3 mm broad, narrowly lanceolate to linear-lanceolate, glabrous above, sparsely pilose to glandular below. Stipules adnate to the petiole, connate, the free ends acuminate, pilose to glabrous dorsally, ciliate. Scape 12-20 cm long. Bracts linear-lanceolate, equalling or longer than the calyx tube, pilose and glandular dorsally. Racemes 6- to 20-flowered, little elongating in fruit. Flowers 11-16 mm long, pink-purple (fading blue-purple). Calyx cylindric, villous with dark and light hairs; tube 5-6 mm; teeth 2.5-4.0 mm, narrowly lanceolate, the dorsal surface glandular and villous. Pods 13-16 mm long including a beak 4-5 mm long, chartaceous, partially 2-celled by intrusion of the ventral suture, strigose with black hairs, glandular-viscid.

The main range of Oxytropis viscida occurs in the western and northwestern parts of North America. However, it is known from localized relict stations as far east as the Gaspe Peninsula, Quebec. Our material has gone under the name of O. ixodes. This "species" is known only from Cook County, Minnesota, and adjacent Canada. As herein interpreted O. ixodes falls within the limits of the O. viscida complex. Had the specimens of O. ixodes originated in the west, rather than in a station remote from the main area of the species, they would have been referred without difficulty to O. viscida.

Barneby (1952) has included our material in the type variety and for the purpose of limiting the synonymy only those names involved with that variety are included in the present paper.

No type has been seen and the writer has based typification of O. viscida on the treatment of Barneby (1952) who cites the type collection (NY, PH).

Beyond our region the species extends from the Gaspe Peninsula, Quebec to northern Canada and Alaska then southward to California and Colorado. The plants in our region grow on rocky hillsides and talus slopes. They flower from late June to mid-July.

ROBINIA L.

Robinia L. Sp. Pl. 722. 1753.
Pseudoacacia Medic. Vorles. Kurpfalz. Physik.-Oekon. Ges. 2:364. 1787.

Shrubs or trees. Leaves odd-pinnate; leaflets petiolulate; stipels shorter or longer than the petiolules. Stipules setaceous and caducous or modified into persistent spines. Inflorescences several- or many-flowered. Flowers showy, whitish or pinkish. Calyx campanulate to turbinate; the teeth triangular or triangular-acuminate. Pods elongate, laterally flattened.

Robinia is a poorly understood genus of about 15 species which is native to the United States and Mexico. The original distribution of several of the species prior to the arrival of white men is often difficult to determine. These are species which have been cultivated in areas far beyond their native ranges, and to some degree secondarily escaped. These same plants have received the attention of nurserymen and gardners. Many horticultural forms have been produced.

Several Robinias occur in our area almost entirely as cultivated ornamentals; they are not native to the north-central states. Botanists, unfortunately, have generally avoided collecting cultivated plants unless the plants escape or persist after cultivation. Hence, our herbarium representation of these kinds in this region is fragmentary and any attempt to understand the present distribution must be incomplete.

Our species can be divided into two natural series on the basis of the degree of fusion of the upper two calyx lobes. Both R. pseudoacacia and R. viscosa have calyces in which the upper two teeth are fused into a lip-like structure. The sinus between the two teeth is very shallow. In R. hispida and R. neomexicana the upper two teeth are separated by a deep sinus and are similar in shape to the other teeth.

Cytological studies of members of the genus indicate a basic chromosome number of 10 (or 11). Three of our species are reported to be diploids and one is believed to represent a triploid.

Key to the Species of Robinia

1. Upper two calyx teeth connate, forming a lip; branchlets and peduncles are hispid.
   2. Branchlets and pednucles glandular-viscid; flowers a rose-pink. R. viscosa
   2. Branchlets and peduncles glabrous; flowers white. R. pseudoacacia
1. Upper two calyx teeth deeply cleft, the lobes triangular-acuminate; branchlets and peduncles or both glandular-hispid.
   3. Branchlets and peduncles densely glandular-hispid; a shrub. R. hispida
   3. Branchlets glabrous; peduncles glandular-hispid or glandular-pubescent; a small tree. R. neomexicana

*Robinia hispida L. (Map 24. Plate XXIII, Fig. A)

Robinia hispida L. Mant. 101. 1767.
Robinia rosea Marsh. Arb. 134. 1785. non R. rosea Mill. 1768.
Robinia hispida Michaux Fl. Bor. Am. 2:65. 1803.
Robinia hispida-rosea Mirb. Nauv. Buham 2:64. 1804.
Robinia montana Bartr. ex Pursh, Fl. Am. Sept. 2:488. 1814. pro syn.
Robinia hispida var. macrophylla DC. Prodr. 2:262. 1825.
Robinia macrophylla Schrad. ex DC., Prodr. 2:262. 1825. pro syn.
Robinia grandiflora Hort. ex Schneider Ill. Handb. Laubh. 2:81. 1907. pro syn. non R. grandiflora L. 1759. non R. grandiflora Ashe 1922.
Robinia hispida var. typica Schneider Ill. Handb. Laubh. 2:81. 1907.
Robinia michauxii Sarg. Bull. Arnold Arb. n. ser. 8:32. 1922.
*Robinia fertilis Ashe Rhodora 25:182. 1923.
Robinia unakae Ashe Jour. Elisha Mitchell Soc. 39:110. 1923.
Robinia hispida var. typica Clausen Gent. Herb. 4:291. 1940.
Robinia hispida var. fertilis (Ashe) Clausen Gent. Herb. 4:291. 1940.

Stoloniferous shrubs to 2 m tall; branchlets and peduncles densely glandular-hispid. Leaves 16-27 cm; leaflets 7-13, 30-60 mm long, 15-40 mm wide, ovate to lance-ovoid, petiolulate, glabrous above, sparsely villous below, obtuse, cuspidate; stipels equalling the petiolules; lower portion of the rachis glandular-hispid. Stipules 9-12 mm long, linear, villous. Peduncles 1-4 cm long. Racemes 4-6 cm long, several-flowered; rachis glandular-hispid. Flowers 18-30 mm long, rose-pink. Calyx broadly campanulate, glandular pubescent; tube 4.5-6.0 mm long; teeth 3.5-7.0 mm long, triangular-acuminate. Pods densely hispid.

Since specimens of this attractive flowering shrub are poorly represented in herbaria it is difficult to determine the extent to which it is cultivated. It is commonly seen in cultivation through the central part of this region.

Plate XXIII. Robinia hispida, A. Inflorescence and leaf.

The cytological nature of material which was presumably R. hispida has been investigated by Kreuter (1930) and Whitaker (1934). Both have reported the somatic chromosome number as 30. Kreuter noted that meiosis was irregular, and that he was unable to get a gametic chromosome count. In somatic material he found that there were 20 small and 10 large chromosomes (a triploid). Whitaker checked for pollen sterility in R. hispida and found that 88% of the pollen was not viable. Possibly because of meiotic failure fruit and seeds are seldom produced by the plant typically known as R. hispida.

Clausen (1940), after reviewing R. hispida, combined R. fertilis with the hispida complex. His photograph of the Linnaean type of R. hispida removed all doubt as to the typification of that species. His photograph of the type of R. fertilis appears to represent a plant which morphologically at least would seem to fall within this complex.

Both Kreuter (1930) and Whitaker (1934) have reported a somatic chromosome number of 30 for R. hispida. Whitaker reported the somatic chromosome number of R. fertilis to be 20. However, since Whitaker did not preserve voucher specimens (C. E. Wood, Cambridge, Mass., personal communitation, 1959) the identity of his material may be open to question. Until further work is done, cytological conclusions must remain in abeyance.

The species is not native to the north-central states; its original range was probably from Virginia and Kentucky to Georgia and Alabama. The flowering time is during June and July.

*Robinia neomexicana A. Gray (Map 24. Plate XXIV, Figs. A,B)

Robinia neomexicana A. Gray Mem. Am. Acad. II. 5:314. 1855.
Robinia neomexicana var. luxuriana Kieck Neuheit.-Off. Zoschen 1892-93: ? 1892. (fide Rehder, 1949).
*Robinia rusbyi Woot and Standl. Contr. U. S. Nat. Herb. 16:140. 1913.
Robinia luxurians (Dieck) Schneider ex Tarouca and Schneider Uns. Freil.-Laubh. ec. 2. 357. fig. 417. 1922. (fide Rehder, 1949).
Robinia luxurians (Dieck) Rydb. N. Am. Fl. 24:227. 1924.
*Robinia breviloba Rydb. N. Am. Fl. 24:227. 1924.
*Robinia subvelutina Rydb. N. Am. Fl. 24:227. 1924.

Shrubs or small trees to 8 m tall. Leaves 10-20 cm long; leaflets 9-19, 10-40 mm long, 2-20 mm wide, lance-oblong to oblong, obtuse, cuspidate, minutely pubescent above and below; stipels shorter than the petiolules. Stipules 5-15 mm long, persistent as spines or soon deciduous. Peduncles 2-4 cm long, glandular-pubescent to hispid throughout. Bracts broadly ovate, equalling the calyx tube, soon deciduous. Racemes 2-6 cm long, several- to many-flowered; the rachis glandular-pubescent. Flowers 15-25 mm long, pink. Calyx campanulate, glandular pubescent; tube 5-8 mm long; teeth 3-5 mm long, triangular-acuminate. Pods 4-8 cm long, glandular-pubescent, glandular-hispid, or rarely glabrous.

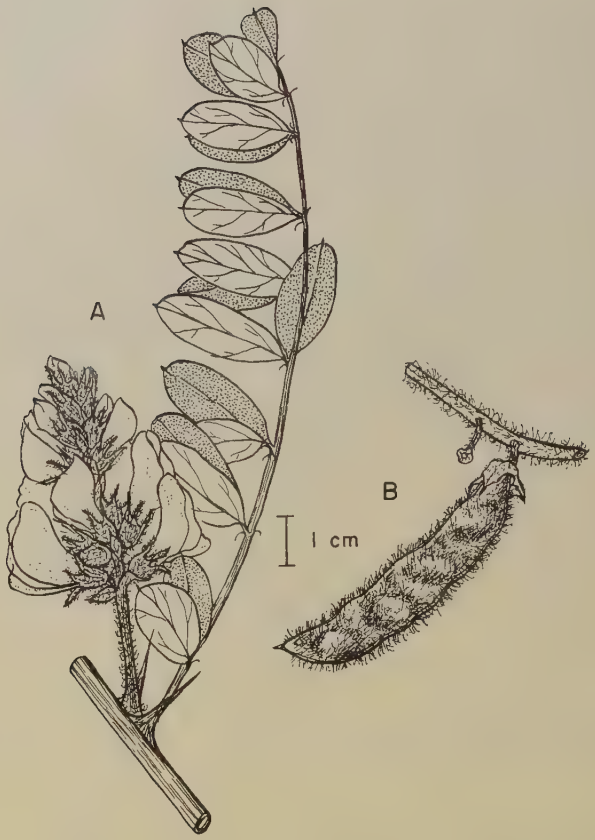


Plate XXIV. Robinia neomexicana, A. Inflorescence and leaf. B. Fruit.

The southwestern complex to which this species belongs has been variously interpreted. Rydberg (1924) recognized five distinct species, Rehder (1951) at least two. Both Harrington (1954) and Kearney and Peebles (1951) recognize only a single species in Colorado and Arizona.

The segregates from R. neomexicana have been based on variations in amount and position of pubescence and on the habit of the plants. R. rusbyi (type, US) was based upon material having glabrous pods. R. breviloba is a depauperate form of R. neomexicana (type, NY) bearing small leaflets and short, curved stipular spines. The type of R. subvelutina (NY) demonstrates it to be a pubescent form. R. luxurians is described as being a small tree with curved stipular spines, puberulent leaflets and leaf rachis, and calyx lobes longer than the tube (Rydberg, 1924). The variability of these segregates appears to be largely the result of varied phenotypic expressions to the different habitats in which the plants grow. The segregates are herein treated as belonging to a single polymorphic species.

The species is represented in the north-central states only in cultivation. The specimens from our region vary considerably in the degree of pubescence and its location on the pods, peduncles, and branchlets. A specimen collected at Stergis, Meade Co., South Dakota (ISC) is only sparsely glandular pubescent and most of the glands are located in the calyx. The upper two calyx teeth are more connate than in other specimens examined.

The distribution of material examined is indicated in Map 24. Owing to the paucity of available material, this is probably a rather incomplete picture.

The native range of this entity is from Colorado to Nevada, south to Texas, Mexico, and Arizona. The plants flower during May, June, and early July.

The somatic chromosome number of R. neomexicana had been reported by Tishler (1938) to be 22.

Robinia pseudoacacia L. (Map 25. Plate XXV, Figs. A,B)

Robinia pseudoacacia L. Sp. Pl. 722. 1753.
Robinia acacia L. Syst. ed. 10. 1161. 1759.
Pseudoacacia odorata Moench Meth. 145. 1794.
Robinia fragilis Salisb. Prodr. 336. 1796.

Trees to 25 m tall; branchlets and peduncles at first finely pubescent, becoming glabrous in age. Leaves 16-28 cm long; leaflets 11-25, 25-60 mm long, 10-30 mm wide, petiolulate, lance-oblong to oblong, obtuse or retuse, cuspidate, pubescent above and below. Stipels minute. Stipules none or present and persisting as spines. Peduncles 1-5 cm long, short-villous. Racemes 3-12 cm long, few- to many-flowered. Flowers 12-20 mm long, whitish (fading yellowish). Calyx broadly campanulate to turbinate, minutely pubescent; tube 3.5-5.5 mm long; teeth 1.5-2.0 mm long, the upper two connate, the sinus shallow. Pods 4-12 cm long, glabrous, woody.

Plate XXV. Robinia pseudoacacia, A. Inflorescence and leaf. B. Fruit.

The species has been widely cultivated throughout the United States and in Europe as well. Many horticultural varieties have been named and are commonly available in nurseries.

The wood of R. pseudoacacia is used as fence posts and is extremely durable in contact with the soil. It is also used as an ornamental and as a soil erosion plant.

R. pseudoacacia is the most widely distributed of the species of Robinia present in the north-central states. The plants are possibly native to southern Indiana, southern Illinois, and much of Missouri (at least the Ozark region). The range of the specimens examined is indicated in Map 25. Beyond our range the plants are presumably native from Pennsylvania to Georgia, Louisiana, and Oklahoma.

The somatic chromosome number has been reported to be 20 by Kreuter (1930) and Whitaker (1934), but Tschechow (1930) reported the somatic number as 22.

Robinia viscosa Vent. (Map 24)

Robinia viscosa Vent. ex Vauq., Bull. Soc. Philom. Paris 1, 2:161. 1799.
Robinia glutinosa Sims Bot. Mag. pl. 560. 1802.
Robinia montana Bartr. ex Bichx., Fl. Bor. Am. 2:65. 1803. pro syn.

Trees to 14 m tall; branchlets, peduncles and petioles glandular-viscid. Leaves 10-15 cm long; leaflets 13-25, 25-35 mm long, 10-18 mm wide, lance-oblong to oblong, minutely pubescent above and below, obtuse, cuspidate; stipels shorter than the petiolules. Stipules none or present and persisting as spines, to 8 mm long. Peduncles 3-4 cm long. Bracts ovoid, acuminate, soon deciduous. Racemes 4-8 cm long, several- to many-flowered. Flowers 18-25 mm long, pink; the standard with a yellow spot. Calyx turbinate, minutely pubescent; tube 4-5 mm long, teeth 2-3 mm long, the upper two connate, the sinus shallow. Pods 4-6 cm long, glandular-hispid.

These plants are cultivated and rarely escape in our region. In some areas they may form extensive growths on abandoned farmsteads or in the strip-mining areas of Indiana.

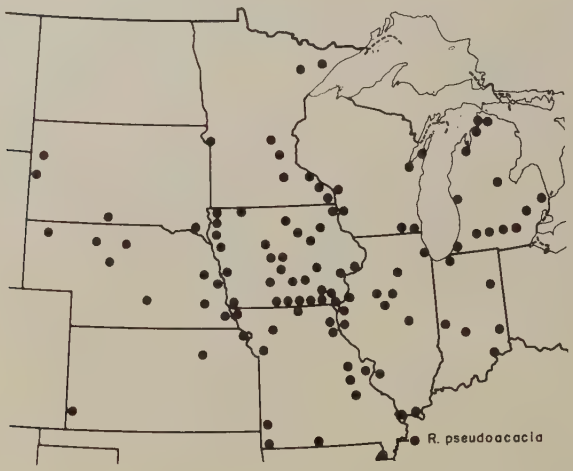
The species was described by C. Ventenat from materials discovered (Vauquelin, 1799, p.161) "dans la Caroline méridionale, sur les monts Allégani, vers les sources de la rivière Savannah." The writer has not seen the type of this species, but Ventenat's description could hardly apply to any other species of Robinia.

The plants are native from Pennsylvania south to Alabama. They flower in June in our region.

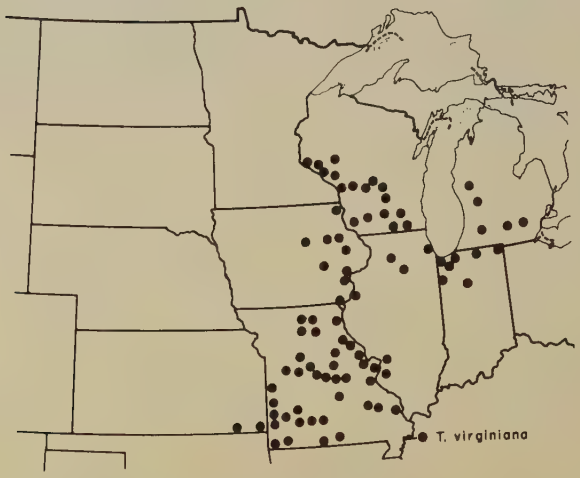
The somatic chromosome number of R. viscosa has been reported to be 20 by Whitaker (1934).

SESBANIA Scop.

Sesbania Scop. Introd. 308. 1777. nom cons. (homonymum prius Sesban Adans).



Map 25. Range of specimens examined of Robinia pseudoacacia.



Map 26. Range of Tephrosia virginiana.

Sesban Adans. Fam. 2:327. 1763.
Darwinia Raf. Fl. Ludov. 106. 1817.

Herbs with evenly pinnate leaves of numerous leaflets. Stipules setaceous. Peduncles shorter than the subtending leaves. Racemes axillary, few- to several-flowered. Flowers papilionaceous, yellowish within, purple-mottled without. Stamens diadelphous. Calyx broadly campanulate to turbinate. Pods linear, the seeds separated by partitions.

Sesbania is a genus of about 50 species which is distributed in the warmer parts of both hemispheres. Some of the members of the genus are of importance for use as green manures in soil improvement. In rice growing regions of the southern states the native species have proved to be troublesome weeds.

The genus has been variously interpreted by taxonomists in the past. In a broad sense the group includes the segregates Sesban, Agati, Daubentonia, Glottidium, and Daubentoniopsis. Rydberg (1924) maintained all of them as distinct genera primarily on the basis of fruit characters. Turner (1955) has suggested, on the basis of cytological investigations, that it is best to treat the genus conservatively. As treated herein, Sesbania is defined on the basis of the single species represented in our area.

Sesbania exaltata (Raf.) Cory (Map 20. Plate XVII, Figs. A-C)

Sesbania exaltata (Raf.) Cory Rhodora 38:406. 1936.
Darwinia exaltata Raf. Fl. Ludov. 106. 1817.
Sesbania macrocarpa Muhl. ex Nutt., Gen. 2:112. 1818.
Sesban exaltatus (Raf.) Rydb. N. Am. Fl. 24:204. 1924.

Erect annual plants to 3 m tall. Leaves 10-25 cm long, even-pinnate; Leaflets 24-70, 10-20 mm long, 2-5 mm wide, narrowly oblong, mucronate, glabrous. Stipules setaceous. Peduncles 2-5 cm long. Bracts setaceous nearly equalling the pedicels. Racemes 2- to 6-flowered. Flowers 15-20 mm long, yellow within, purple-mottled without. Calyx campanulate, glabrous; tube 4.5-6.0 mm long; teeth 1.5-2.5 mm long, triangular. Pods 10-20 cm long, linear; the tip prolonged as a beak; the seeds separated by transverse partitions.

S. exaltata has been used to some extent as a green manure and as a cover plant in wildlife plantings in the southeastern part of the United States. It is also frequently a weed in irrigated rice fields. In our area S. exaltata is relegated to the position of a weed of wet alluvial soils.

It is possible that S. exaltata is identical to the tropical species S. emerus (Aubl.) Urb. However, until it is possible to do further study of this complex and to adequately typify the members it is better to treat our material as a distinct species.

Beyond our region the species extends southwestward to Texas and eastward to Florida. The plants grow in low, moist areas, along streams and in waste lands. They flower during August and September.

Turner (1955) has reported the somatic chromosome number of S. exaltata to be 12.

TEPHROSIA Pers.

Tephrosia Pers. Syn. 2:328. 1807. nom. cons. (homonymum prius Cracca L.).
Cracca L. Sp. Pl. 752. 1753. non Cracca Benth 1853.
Galega L. Syst. ed. 10. 1172. 1759. pro parte.

Perennial herbs with long roots. Leaves odd-pinnate, stipulate. Inflorescences terminal, or if axillary then arising opposite the leaves. Flowers papilionaceous. Stamens diadelphous (the vexillar-stamen frequently partially fused). A collar-like receptacle present at the base of the ovary within the staminal tube. Calyx broadly campanulate, the lanceolate lobes exceeding the tube. Pods linear, dehiscent.

Tephrosia is a large genus of perhaps 250 species which is widespread in the warm regions of both hemispheres. They are especially numerous in tropical Africa and in Australia. In this country the bulk of the species, about 15, are known from the southeastern states.

Several of the species produce rotenone and related compounds and are thus a potential source of insecticides. The plants have been used as fish poisons in Australia, Africa, Asia, and America. Tephrosia species have also been used in tropical agriculture as green manures, cover-crops, and soil binders.

Only a single species is present in our region.

Tephrosia virginiana (L.) Pers. (Map 26. Plate XXVI, Figs. A,B)

Tephrosia virginiana (L.) Pers. Syn. Pl. 2:329. 1807.
Cracca virginiana L. Sp. Pl. 752. 1753.
Galega virginiana L. Syst. ed. 10. 1172. 1759.
Galega virginica J.F. Gmel. Syst. Nat. 2:1552. 1791.
Tephrosia holosericea Nutt. Jour. Acad. Phila. 7:105. 1834.
Tephrosia virginiana var. holosericea (Nutt.) T. and G. Fl. N. Am. 1:296. 1838.
Cracca virginiana var. holosericea (Nutt.) Vail Bull. Torrey Club 22:27. 1895.
Cracca holosericea (Nutt.) Britt. and Baker Jour. Bot. 38:15. 1900.
Cracca leucosericea Rydb. N. Am. Fl. 24:163. 1923.
Tephrosia leucosericea (Rydb.) Cory Rhodora 38:406. 1936.
Tephrosia virginiana var. leucosericea (Rydb.) Herm. Jour. Wash. Acad. Sci. 38:237. 1948.

Plants perennial; stems 30-60 cm tall, erect, several from a branching caudex, villous with spreading hairs. Stipules 5-10 mm long, setaceous, caducous. Leaves 8-11 cm long, odd-pinnate; leaflets 17-29, 15-30 mm long, 4-8 mm wide, narrowly oblong to elliptic, mucronate, villous above and below or glabrous above. Inflorescences terminal or occasionally axillary, 3-15 cm long. Flowers 15-20 mm long, several to many, the banner yellowish, the wings and keel pinkish or purplish; the banner dorsally strigose. Calyx campanulate, densely villous; tube 2.5-4.5 mm long, teeth 3.5-7.0 mm long, lanceolate. Pods 3.5 cm long, linear-oblong, villous, erect or spreading.

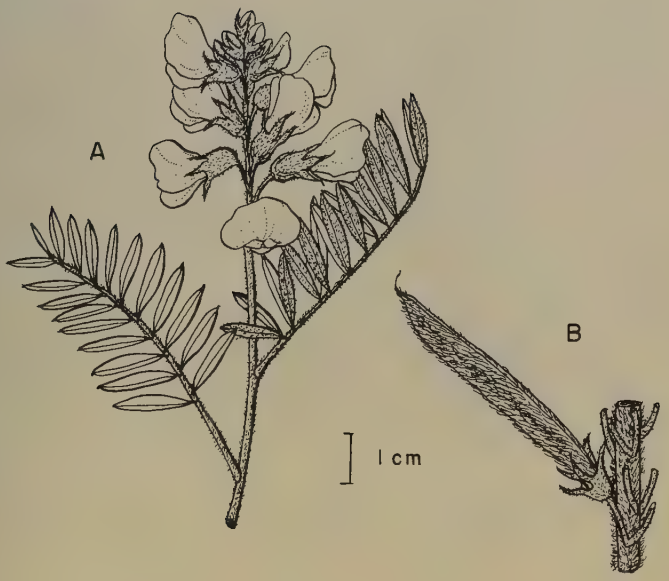


Plate XXVI. Tephrosia virginiana, A. Inflorescence and leaves. B. Fruit.

There is a considerable degree of variation in the amount and position of the pubescence in T. virginiana. Most of our material is hairy on both leaf surfaces but occasional specimens have glabrous upper leaf surfaces. Wood (1949) has discussed the variability of this species with respect to the varieties which have been proposed. He concluded that T. virginiana was a single, widespread, genetically diverse species lacking in both distinct morphological and geographical variations, but which tends to be more pubescent in the northwestern part of its range.

Beyond our region the species extends south to Texas and east to Florida and north to New Hampshire and Ontario. The plants grow in sand dunes, open woods, and in prairies. The blooming period extends from late May to mid-July.

Both Senn (1938) and Wood (1949) have reported the somatic chromosome number to be 22.

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REFERENCES

Abrams, L. 1951. Illustrated Flora of the Pacific States. Vol. 1. Stanford, California, Stanford University Press.

Adanson, M. 1763. Familles des Plantes, Vol. 2. Paris: Vincent.

Ashe, W.W. 1897. Robinia boyntonii sp. nov. Jour. Elisha Mitchell Soc. 14:51-55.

_____. 1923. Notes on shrubs of the southeastern states. Jour. Elisha Mitchell Soc. 39:110-111.

Bailey, L.H. 1949. Manual of Cultivated Plants. New York: The Macmillan Company.

Barneby, R.C. 1944. Pugillus Astragalorum III. Leafl. West. Bot. 4:49-63.

_____. 1946. Pugillus Astragalorum V. Leafl. West. Bot. 4:228-238.

_____. 1947a. Pugillus Astragalorum VI: Notes on section Drabellae. Leafl. West. Bot. 5:1-9.

_____. 1947b. Pugillus Astragalorum VII: A revision of the Argophylli. Am. Midl. Nat. 37:421-516.
_____. 1947c. Pugillus Astragalorum VIII. Notes on section Genistoidei. Leafl. West. Bot. 5:25-35.
_____. 1951a. Pugillus Astragalorum XIII. The varieties of A. tegetarius Wats. (Kentrophyta Nutt.). Leafl. West. Bot. 4:89-102.
_____. 1951b. New names in Oxytropis. Leafl. West. Bot. 4:111.
_____. 1952. A revision of the North American species of Oxytropis DC. Proc. Cal. Acad. Sci. 27:117-312.
_____. 1956a. Pugillus Astragalorum XVIII: Miscellaneous novelties and reappraisals. Am. Midl. Nat. 55:477-503.
_____. 1956b. Pugillus Astragalorum XIX: Notes on A. sericoleucus Gray and its immediate relatives. Am. Midl. Nat. 55:504-507.
Bates, J.M. 1895. A new Astragalus. Am. Nat. 29:607-671.
_____. 1905. Shorter notes. Torreya 5:215-216.
Beal, W.J. 1904. Michigan Flora. Lansing, Michigan: Robert Smith Printing Co.
Beath, O.A. 1937. The occurrence of selenium and seleniferous vegetation in Wyoming. II. Seleniferous vegetation. Wyo. Agr. Exp. Sta. Bull. 221:29-64.
Beck, L.C. 1833. Botany of the Northern and Middle States. Albany: Webster and Skinners.
Bigelow, Jr. 1824. Florula Bostoniensis. Boston: Cummings, Hilliard and Co.
Blake, S.F. and A.C. Atwood. 1942. Geographical guide to the Floras of the World. Washington: U.S. Government Printing Office.
Blankinship, J.W. 1905. Supplement to the flora of Montana: additions and corrections. Mont. Agr. Coll. Stud. 1:35-109.
Boissier, E. 1859. Diagnoses Plantarum Orientalium Novarum Vol. 6. Lipsiae: A.B. Hermann.
Boltwood, H.L. 1880. Notes from Illinois. Bot. Gaz. 5:71.
Brandegee, K. 1894. The dates of Botany Beechy, Flora Boreali-Americana, and Torrey and Grays Flora. Zoe 4:369-372.
Britten, J. and E.G. Baker. 1900. On some species of Cracca. Jour. Bot. 38:12-19.
Britton, N.L. 1901. Manual of the Flora of the Northern States and Canada. New York: Henry Holt and Co.
_____. 1905. The Flora of the Northern United States and Canada. New York: Henry Holt and Co.
_____., ed. 1894. List of Pteridophyta and Spermatophyta growing without cultivation in northeastern North America. Mem. Torrey Club. 5:9-377.
_____ and H.A. Brown. 1897. Illustrated Flora. Vol. 2. New York: Charles Scribner's and Sons.
Brown, R. 1825. Carmichaelia. Bot. Reg. 11: t. 912.
Buckley, S.B. 1863. Distribution of new plants from Texas. Proc. Acad. Phila. 1861:452.
Bunge, A. 1869. Generis Astragali Species Gerontogaeae. Mem. Acad. Sci. St.-Petersbourg. Ser. 7. 15:1-254.
Butters, F.K. and E.C. Abbe. 1943. A new Oxytrope of the Minnesota-Ontario border. Rhodora 45:2-4.

Candolle, A.P.de. 1802. Astragalogia. Parisiis: Joann Bapt Garnery.
_____. 1825. Prodromus Systematis Naturalis Regni Vegetabilis. Vol. 2. Parisiis: Treutel.
_____. 1825. Memoires sur la famille des Legumineuses. Paris: A. Belin.
_____ and A. de Candolle. 1833. Les Plantes Rares. Mem. Soc. Phys. Hist. Nat. Geneve. 6:209-253.
Chapman, A.W. 1860. Flora of the Southern United States. 1st ed. New York: Ivison, Phinney, and Co.
Clarkson, R.B. 1958. The genus Robinia in West Virginia. Castanea 23:56-58.
Clausen, R.T. 1940. On the status of Robinia hispida. Gent. Herb. 4:287-292.
Clements, F.E. and E.S. Clements. 1920. Rocky Mountain Flowers. New York: H.W. Wilson Co.
Clute, W.N. 1907. The single-leaved locust (Robinia pseudoacacia monophylla). Am. Bot. 13:63.
Cockerell, T.D.A. 1902. Some New Mexico plants. Torreya 2:154-156.
_____. 1918. Notes on the flora of Boulder County, Colorado. Torreya 18:177-183.
Compton, R.H. 1912. An investigation of the seedling structure in the Leguminosae. Jour. Linn. Soc. Bot. 41:1-122.
Cory, V.L. 1936. New names and new combinations for Texas plants. Rhodora 38:404-408.
Coulter, J.M. and A. Nelson. 1909. New Manual of Botany of the Central Rocky Mountains. New York: American Book Co.
Cronquist, A. 1943. The varieties of Astragalus decumbens. Leafl. West. Bot. 3:250-254.
_____. 1953. Notes on specimens of American plants in European herbaria. Leafl. West. Bot. 7:17-31.
_____. 1957. Fraser's Catalogue again. Rhodora 59:100.
_____, D.D. Keck, and B. Maguire. 1956. Validity of Nuttall's names in Fraser's Catalogue. Rhodora 58:23-24.
Daniels, F.P. 1911. The flora of Boulder, Colorado and vicinity. Univ. Mo. Stud. (Sci. ser.) 2:1-311.
Darlington, C.D. and A.P. Wylie. 1955. Chromosome Atlas of the Flowering Plants. New York: Macmillan Publishing Co.
Deam, C.C. 1940. Flora of Indiana. Indianapolis: Wm. B. Buford Printing Co.
Don, G. 1832. A General System of Gardening and Botany. Vol. 2 London: J.G. and F. Rivington.
Duhamel, H.L. 1804. Traite des arbres et arbustes que l'on cultive en France. Nouvelle Edition. Paris: Etienne Michel.
Eaton, A. and J. Wright. 1840. North American Botany. Troy, New York: Elias Gates.
Elliott, S. 1824. Sketch of the Botany of South Carolina and Georgia. Charleston: J.R. Schenck.
Engelmann, G. 1844. Catalogue of a collection of plants made in Illinois and Missouri by Chas. A. Geyer. Am. Jour. Sci. and Arts 46:94-104.
Fassett, N.C. 1936. Notes from the herbarium of the University of Wisconsin XIII. Rhodora 38:94-97.

_____. 1939. The Leguminous Plants of Wisconsin. Madison: University of Wisconsin Press.
_____. 1957. Spring Flora of Wisconsin. Madison: University of Wisconsin Press.
Fernald, M.L. 1928. The genus Oxytropis in northeastern America. Rhodora 30:137-155.
_____. 1932. Rydberg's flora of the prairies and plains. Rhodora 33: 243-247.
_____. 1937. IV. Nomenclatural transfers and new varieties and forms. Rhodora 39:309-320.
_____. 1945. An incomplete flora of Illinois. Rhodora 47:204-219.
_____. 1950. Gray's Manual of Botany. 8th ed. New York: American Book Co.
_____ and S.L. Kelsey. 1928. A new Oxytropis from the Gaspe Coast. Rhodora 30:121-124.
Fox, W.B. 1945. The Leguminosae in Iowa. Am. Midl. Nat. 34:207-230.
Freyn, J. 1893. Plantae novae Orientales. Ost. Bot. Zeit. 43:415.
Gambill, W.G., Jr. 1953. The Leguminosae of Illinois. Urbana: University of Illinois Press.
Gams, H. 1956. Die Tragacantha-Igelheiden der Gaberg um das Kaspische, schwarze und mittellandisch Meer. Veroffentl. geobot. Inst. Rubel Zurich 31:217-243.
Gandoger, M.M. 1901. Les Astragalus Americains. Bull. Soc. Bot. Fr. 48: xiii-xviii.
Gates, F.C. 1939. New forms and nomenclatural combinations in the Kansas flora. Trans. Kansas Acad. Sci. 42:135-138.
_____. 1940. Annotated list of the plants of Kansas: ferns and flowering plants. Kansas State College, Dept. of Botany. Contr. 399.
Gattinger, A. 1901. The flora of Tennessee. Nashville: Gospel Advocate.
Gay, P.C. 1846. Flora Chilena, Historia de Chille. Vol.2 Paris: De Faine Y Thunot.
Gleason, H.A. 1947. The preservation of well known binomials. Phytologia 2:201-212.
_____. 1952. Illustrated Flora. Vol.2. Lancaster, Pa.: Lancaster Press Inc.
Gmelin, J.F. 1791. Caroli Linne Systema Naturae. 13th ed. Vol.2. Lipsiae: Georg Emanual Beer.
Goeze, E. 1892. Notes from Germany. Gard. Chron. III. 12:668-670.
Graustein, J.E. 1956. Nuttall's quarrel with Pursh. Rhodora 58:20-22.
Gray, A. 1849. Plantae Fendlerianae Novi-Mexicanae. Mem. Am. Acad. 4:1-116.
_____. 1852. Plantae Wrightianae Texano-Neo-Mexicanae. Part 1. Smiths. Contr. Knowl. 3:5-146.
_____. 1853. Plantae Wrightianae Texano-Neo-Mexicanae. Part 2. Smiths. Contr. Knowl. 5:5-116.
_____. 1855. Plantae novae Thurberianae: the characters of some new genera and species of plants in a collection made by George Thurber, Esq. of the late Mexican Boundary Commission, chiefly in New Mexico and Sonora. Mem. Am. Acad. II. 5:298-328.

_____. 1856. Manual of Botany of the Northern United States. 2nd ed. New York: George P. Putnam.

_____. 1859. Catalogue of plants collected east of the Rocky Mountains. Rep. Explor. Surv. Miss. Pac. Vol. 12. Washington: Thomas H. Ford, Printer.

_____. 1862. Enumeration of the plants of Dr. Parry's collection in the Rocky Mountains in 1861. Am. Jour. Sci. II. 33:404-411.

_____. 1863. Enumeration of the species of plants collected by Dr. C.C. Parry, and Messrs. Elihu Hall and J.P. Harour, during the summer and autumn of 1862, on and near the Rocky Mountains, in Colorado Territory, lat. 39°-41°. Proc. Acad. Phila. 1863:55-80.

_____. 1864. A revision and arrangement (mainly by the fruit) of the North American species of Astragalus and Oxytropis. Proc. Am. Acad. 6:188-236.

_____. 1883. Contributions in North American Botany. Proc. Am. Acad. 19:1-97.

_____. 1884. A revision of the North American species of Oxytropis DC. Proc. Am. Acad. 20:1-7.

Greene, E.L. 1890. Reprint of Fraser's Catalogue. Pittonia 2:114-119.

_____. 1893. Corrections in nomenclature III. Erythea 1:206-208.

_____. 1895. Corrections in nomenclature VII. Erythea 3:75-76.

_____. 1897. Corrections in nomenclature II. Pittonia 3:207-212.

_____. 1899. New or noteworthy species. Pittonia 4:68-72.

_____. 1905. Diagnoses Aragallorum. Proc. Biol. Soc. Wash. 18:11-17.

Harrington, H.D. 1954. Manual of the Plants of Colorado. Denver: Sage Books.

_____ and L.W. Durrell. 1957. How to Identify Plants. Denver: Sage Books.

Harvey, G.A. 1947. Douglas of the Fir. Cambridge, Mass.: Harvard University Press.

Head, S.C. 1957. Mitotic chromosome studies in the genus Astragalus. Madrono 14:95-106.

Hegi, G. 1906. Illustrierte Flora von Mittel-Europa. IV. Band. 3 Teil. Munchen: J.F. Lehmanns.

Heller, A.A. 1898. Catalogue of North American plants north of Mexico. By the author: no place of publication given.

_____. 1899. New and interesting plants from western North America VI. Bull. Torrey Club 26:547-552.

_____. 1900. Catalogue of North American plants north of Mexico. 2nd ed. By the author: no place of publication given.

Harshberger, J.W. 1899. The Botanists of Philadelphia and their Work. Philadelphia: T.C. Davis and Sons.

Herman, F.J. 1948. Notes on North American Leguminosae. Jour. Wash. Acad. Sci. 38:236-238.

Hooker, W.J. 1829-1834. Flora Boreali-Americana. Vol.1. London: Henry G. Bohn.

_____. 1847. Catalogue of Mr. Geyer's collection of plants gathered in the upper Missouri, the Oregon Territory, and the intervening portion of the Rocky Mountains. Lond. Jour. Bot. 6:206-256.

Horr, W.H. and R.L. McGregor. 1952. Kansas plants new to Kansas herbaria VII: including a new form of Zinnia grandiflora and Petalostemon purpureum. Trans. Kans. Acad. Sci. 55:172-175.

Isely, D. 1951. The Leguminosae of the north-central United States. I. Loteae and Trifolieae. Iowa State Coll. Jour. Sci. 25:439-482.

_____. 1955. The Leguminosae of the north-central United States. II. Hedysareae. Iowa State Coll. Jour. Sci. 30:33-118.

_____. 1958. Leguminosae of the north-central United States. III. Mimosoideae and Caesalpinioideae. Iowa State Coll. Jour. Sci. 32: 355-393.

Jackson, B.D. 1881. Guide to the Literature of Botany. London: Longmans, Greene and Co.

_____. 1893. Bibliographical notes. Bull. Herb. Boiss. 1:297-299.

_____. 1895. Index Kewensis. Oxford: The Clarendon Press.

Jacquin, N.J. 1776. Hortus Botanicus Vindobonensis. Vol. 3. Vindobonae: Josephi Michaelis Gerold.

James, E.P. 1825. Catalogue of plants collected during a journey to and from the Rocky Mountains, during the summer of 1820. Trans. Am. Phil. Soc. (new ser.) 2:172-190.

Jepson, W.L. 1936. A Flora of California. Vol. 2. Berkeley, Cal.: University of California Press.

Jones, G.N. 1938. The flowering plants and ferns of Mount Rainier. Univ. Wash. Pub. Bot. 7:5-192.

_____. 1945. Flora of Illinois. Notre Dame, Indiana: The University Press.

_____ and G.D. Fuller. 1955. Vascular Plants of Illinois. Urbana: The University of Illinois Press.

Jones, M.E. 1893. Contributions to western botany IV. Zoe 4:22-54.

_____. 1895. Contributions to western botany VII. Proc. Cal. Acad. II. 5:611-733.

_____. 1898. Contributions to western botany VIII. Contr. West. Bot. 8:8.

_____. 1902. Contributions to western botany X. Contr. West. Bot. 10: 1-90.

_____. 1923. Revision of North-American species of Astragalus. Salt Lake City, Utah: by the author.

Kearney, T.H. 1945. A new name in Astragalus. Leafl. West. Bot. 4:216.

_____. 1946. Leaf hairs of Astragalus. Leafl. West. Bot. 4:223-227.

_____ and R.H. Peebles. 1951. Arizona Flora. Berkeley, Cal.: University of California Press.

Kelso, E.H. 1937. Notes on Rocky Mountain plants. Rhodora 39:149-152.

Ker, J.B. 1816. Astragalus caryocarpus. Edward's Bot. Reg. 2: pl. 176.

Koch, K. 1869. Polypetaleae. Dendr. 1:3-735.

Koehne, E. 1893. Deutsche Dendrologie. Stuttgart: Ferdinand Enke.

_____. 1906. Uber neue oder interessante Holzgewachse. Mitt. Deutsch. Dendr. Ges. 1906:51-69.

_____. 1913. Ein neue Robinie. Mitt. Deutsch. Dendr. Ges. 22:1-3.

Komarov, V.L. 1908. Monograph of Caragana. Acta Horti Petropolitani 29:179-399.

Kreuter, E. 1929. Chromosomenstudien bei den Galegeen. Ber. Deutsch. Ges. 47:99-101.

_____. 1930. Beitrag zu Karyologisch-systematischen Studien an Galegeen. Planta 11:1-44.
Kuntze, O. 1891. Revisio Genera Plantarum. Pars 1. Wurzburg: H. Sturtz.
_____. 1891. Revisio Genera Plantarum. Pars 2. Wurzburg: H. Sturtz.
Lamarck, C. de. 1783. Encyclopedie Methodique Botanique. Vol. 1. Paris: Panckoucke.
Lanjouw, J., ed. 1956. International Code of Botanical Nomenclature. Utrecht, Netherlands: Kemink en Zoon.
_____ and F.A. Stafleu. 1959. Index Herbariorum. Part 1. 4th ed. Utrecht, Netherlands: Kemink en Zoon.
Ledingham, G.F. 1957. Chromosome numbers of some Saskatchewan Leguminosae with particular reference to Astragalus and Oxytropis. Canad. Jour. Bot. 35:657-666.
Lindley, J. 1830. Astragalus succulentus. Edward's Bot. Reg. 16: pl. 1324.
Linnaeus, C. 1753. Species Plantarum. Vol. 2. Holmiae: Laurentii Salvii.
_____. 1759. Systema Naturae. 10th ed. Holmiae: Laurentii Salvii.
_____. 1767. Mantissa Plantarum. Generum editionis VI. et Specierum editionis II. Holmiae: Laurentii Salvii.
_____. 1771. Mantissa Plantarum altera. Holmiae: Laurentii Salvii.
Lunell, J. 1908. New matter of the season. Bull. Leed's Herb. 2:6-7.
_____. 1911. I. New plants from Minnesota. Am. Midl. Nat. 2:127-128.
_____. 1916. The vascular plants of North Dakota VII. Am. Midl. Nat. 4:419-431.
Macbride, J.F. 1922. A revision of Astragalus, subgenus Homalobus, in the Rocky Mountains. Contr. Gray Herb. 65:28-39.
MacMillan, C. 1892. The Metaspermae of the Minnesota Valley. Minneapolis: Harrison and Smith.
Marshall, H. 1785. Arbustum Americanum. Philadelphia: Joseph Crukshank.
McIntosh, A.C. 1931. A botanical survey of the Black Hills of South Dakota. Black Hills Engineer 19:157-276.
Marschall von Bieberstein, L.B.F. 1808. Flora Taurico-Caucasica. Vol. 2. Charkouiae: Typis Academicis.
Michaux, A. 1803. Flora Boreali-Americana. Vol. 2. Parisiis et Argentorati: Levrault.
_____. 1820. Flora Boreali-Americana. Vol. 1. Parisiis: Bibliopola Journaux.
Miller, P. 1768. The Gardener's Dictionary. London: by the author.
Moench, C. 1794. Methodus Plantas. Horti Botanici et Agri Marburgensis. Marburgi: officina nova libraria academiae.
Moore, J.A. 1936. The vascular anatomy of the flower in the papilionaceous Leguminosae. Am. Jour. Bot. 23:349-355.
Moore, J.W. 1957. Notes on flowering plants in Minnesota. Rhodora 59:6-8.
_____ and R.M. Tryon, Jr. 1946. A preliminary check list of the flowering plants, ferns and fern allies of Minnesota. Minneapolis: Dept. of Bot. Univ. of Minn.

Moyle, J.B. 1938. A Field Key to the More Common Non-Woody Vascular Plants of Central and Northern Minnesota. Minneapolis: Burgess Publishing Co.

Necker, J. de. 1790. Elementa botanica. Vol. 3. Rhenum: apud societatem typographicam.

Nelson, A. 1896. First report on the flora of Wyoming. Bull. Wyo. Exp. Sta. 28:48-218.

_____. 1898. New plants from Wyoming III. Bull. Torrey Club 25:373.

_____. 1899. The western species of Aragallus. Erythea 7:57-64.

_____. 1899. Correction in Aragallus. Erythea 7:189-190.

_____. 1899. New plants from Wyoming V. Bull. Torrey Club 26:5-11.

_____. 1912. Contributions from the Rocky Mountain herbarium. XI. New plants from Idaho. Bot. Gaz. 54:136-151.

_____. 1926. Taxonomic studies. Univ. Wyo. Pub. Sci. 1:109-143.

Nuttall, T. 1818. The Genera of North American Plants. Vol. 2. Philadelphia: D. Heartt.

_____, 1819. Travels into the Arkansas Territory, 1819. In Thwaites, R.G. 1905. Early Western Travels 1748-1846. pp. 1-348. Cleveland: The Arthur H. Clark Co.

_____. 1834. A catalogue of a collection of plants made chiefly in the valleys of the Rocky Mountains or northern Andes, towards the sources of the Columbia River, by Mr. Nathanial B. Wyeth. Jour. Acad. Phila. I. 7:5-60.

_____. 1834. A description of some of the rarer or little known plants indigenous to the United States, from the dried specimens in the herbarium of the Academy of Natural Sciences in Philadelphia. Jour. Acad. Phila. I. 7:61-115.

Over, W.H. 1932. Flora of South Dakota. Vermillion: University of South Dakota.

Pallas, P.S. 1773. Reise durch verschiendene Brodinzen des Russischen Reichs. St. Petersburg: Druckerei der Akademie der Wissenschaften.

_____. 1783. Descriptiones Plantarum Sibiriae Peculiarium. Acta Acad. Petrop. 2:268.

_____. 1800. Species Astragalorum. Lipsiae: Godofredi Martini.

Palmer, E.J and J.A. Steyermark. 1935. An annotated catalogue of the flowering plants of Missouri. Ann. Mo. Bot. Garden 22:375-758.

Parks, J.O. 1950. Leguminosae (Pea Family) of the Trans-Pecos region of Texas. Unpublished Masters Thesis. Sul Ross State College, Alpine, Texas.

Peck, M.E. 1941. A Manual of the Higher Plants of Oregon. Portland: Binfords and Mort.

Pennell, F.W. 1936. Travels and scientific collections of Thomas Nuttall. Bartonia 18:1-51.

Persoon, C.H. 1807. Synopsis Plantarum. Vol.2. Parisiis Lutetiorum: Treuttel.

Peterson, N.F. 1923. Flora of Nebraska. Lincoln: Woodruff Printing Co.

Petzold, E. and G. Kirchner. 1864. Arboretum Muscaviense. Gotha: W. Opetz.

Piper, C.V. 1906. Flora of Washington. Contr. U.S. Nat. Herb. 11: 9-637.

_____ and R.E. Beattie. 1915. Flora of the North West Coast. Lancaster, Pa.: The New Era Printing Co.
Poiret, J.L.M. 1810. In Lamarck, M. Encyclopédie Méthodique Botanique. Suppl. I. Paris: H. Agasse.
_____. 1811. In Lamarck, M. Encyclopédie Méthodique Botanique. Suppl. II. Paris: H. Agasse.
_____. 1816. In Lamarck, M. Encyclopédie Méthodique Botanique. Suppl IV. Paris: H. Agasse.
Polunin, N. 1959. Circumpolar Arctic Flora. Oxford: The Clarendon Press.
Porter, C.L. 1939. A revision of the subgenus Diholcos of the genus Astragalus. Am. Jour. Bot. 26:690-693.
_____. 1945. Two Tioid Astragalus novelties from the Rocky Mountain region. Madrono 8:99-102.
_____. 1951. Astragalus and Oxytropis in Colorado. Univ. Wyo. Pub. 16:1-49.
_____. 1954. Astragalus in Harrington, H.D. Flora of Colorado. Denver: Sage Books.
Pritzel, G.A. 1872. Thesaurus Literature Botanicae. Lipsiae: F.A. Brockhaus.
Pursh, F. 1814. Flora Americae Septentrionalis. Vol. 2. London: White, Cochrane, and Co.
Rafinesque, C.S. 1832. Twenty new genera of plants from the Oregon Mts. & c. Atlantic Journal and Friend of Knowledge. 1:144-146.
_____. 1817. Florula Ludoviciana or a Flora of the State of Louisiana New York: C. Wiley and Co.
_____. 1836. New Flora of North America. Part 1. Philadelphia: by the author.
Rehder, A. 1922. New species, varieties and combinations from the herbarium and the collections of the Arnold Arboretum. Jour. Arnold Arb. 3:11-51.
_____. 1949. Bibliography of cultivated trees and shrubs. Jamaica Plain, Mass.: Arnold Arboretum.
_____. 1951. Manual of Cultivated Trees and Shrubs. New York: The Macmillan Co.
Richardson, J. 1823. In Franklin, John. Narrative of a journey to the shores of the polar sea. Botanical Appendix. London: John Murray.
Rickett, H.W. 1944. The classification of inflorescences. Bot. Rev. 10:187-231.
Ritter, N. 1917. Histology of Astragalus mollissimus. Kans. Univ. Sci. Bull. 20:197-208.
Rydberg, P.A. 1894. A revision of the nomenclature of the Nebraska Polypetalae. Bot. Surv. Neb. 3:20-39.
_____. 1895. Flora of the sand hills of Nebraska. Contr. U.S. Nat. Herb. 3:133-200.
_____. 1895. Flora of Nebraska. XVI. Part 21. Rosales. Lincoln: Jacob North and Co.
_____. 1896. Flora of the Black Hills of South Dakota. Contr. U.S. Nat. Herb. 3:463-536.
_____. 1900. Flora of Montana. Mem. N.Y. Bot. Gard. 1:1-492.

_____. 1901. Studies on the Rocky Mountain flora. IV. Bull. Torrey Club 28:20-38.
_____. 1905. Astragalus and its segregates as represented in Colorado. Bull. Torrey Club 32:657-668.
_____. 1906. Flora of Colorado. Ft. Collins: Colorado Agricultural College Experiment Station.
_____. 1907. Studies on the Rocky Mountain flora. XVIII. Bull. Torrey Club 34:417-437.
_____. 1913. Studies on the Rocky Mountain flora. XXVIII. Bull. Torrey Club 40:43-74.
_____. 1923. Galegeae. N. Am. Fl. 24:156-200.
_____. 1924a. Galegeae. N. Am. Fl. 24:201-250.
_____. 1924b. Notes on Fabaceae. III. Bull. Torrey Club 51:13-23.
_____. 1925a. Notes on Fabaceae. IV. Bull. Torrey Club 52:143-156.
_____. 1925b. Notes on Fabaceae. V. Bull. Torrey Club 52:229-235.
_____. 1926. Notes on Fabaceae. VII. Bull. Torrey Club 53:161-169.
_____. 1927. Notes on Fabaceae. IX. Bull. Torrey Club 54:321-336.
_____. 1928a. Notes on Fabaceae. X. Bull. Torrey Club 55:119-132.
_____. 1928b. Notes on Fabaceae. XI. Bull. Torrey Club 55:155-164.
_____. 1928c. Genera of American Fabaceae. V. Astragalus and related genera. Am. Jour. Bot. 15:584-595.
_____. 1929a. Notes on Fabaceae. XII. Astragalus L. Bull. Torrey Club 56:539-554.
_____. 1929b. Astragalinae. N. Am. Fl. 24:251-462.
_____. 1930a. Notes on Fabaceae. XIII. Bull. Torrey Club 57:397-407.
_____. 1930b. Genera of North American Fabaceae. VII. Astragalus and related genera (contd.). Am. Jour. Bot. 17:231-238.
_____. 1932. Flora of the Prairies and Plains of Central North America. New York: New York Botanical Garden.
_____. 1954. Flora of the Rocky Mountains. New York: Hafner Publishing Co.
St. John, H. 1928. A revision of the loco-weeds of Washington. Proc. Biol. Soc. Wash. 41:97-106.
Salisbury, R.A. 1796. Prodromus Stirpium in Horto ad Chapel Allerton Vigentium. Londini: William Wesley.
Sargent, C.S. 1922. Early Locusts. Bull. Arnold Arb. new ser.). 8:32.
_____. 1933. Manual of the Trees of North America. 2nd ed. Boston: by the author.
Schneider, C.K. 1907. Illustriertes Handbuch der Laubholzkunde. Jena: Gustave Fischer.
Schumann, K. 1901. Neue Arten der Siphonogamen 1899. Just's Bot. Jahresb. 27:449-545.
_____. 1903. VII. Neue Arten der Phanerogamen 1901. Just's Bot. Jahresb. 29:501-584.
Schwarten, L. and H.W. Rickett. 1958. Abbreviations of titles of serials cited by botanists. Bull. Torrey Club 85:277-300.
Scopoli, I.A. 1797. Introductio ad Historium Naturalem. Pragae: Wolfgangum Gerle.
Senn, H.A. 1938. Chromosome number relationships in the Leguminosae. Bibl. Genet. 12:175-345.

Sheldon, E.P. 1894. On the nomenclature of some North American species of Astragalus. Minn. Bot. Stud. 1:19-24.
_____. 1894. Revised description of the Minnesota Astragali. Minn. Bot. Stud. 1:54-61.
_____. 1894. A preliminary list of the North American species of Astragalus. Minn. Bot. Stud. 1:116-175.
Shinners, L.H. 1955. Non validity of Nuttalian names in Fraser's Catalogue. Rhodora 57:290-293.
_____. 1956. Nuttall not the author of Fraser's Catalogue. Rhodora 58:281-289.
_____. 1958. Spring Flora of the Dallas-Fort Worth Area. Dallas, Texas: by the author.
Sims, J. 1801. Curtis's Botanical Magazine. Fol. 15. London: Stephen Couchman.
_____. 1819. Curtis's Botanical Magazine. Vol. 46. London: Sherwood, Neely, and Jones.
Small, J.K. 1898. Studies in the botany of the southern United States. XIII. Bull. Torrey Club 25:134-151.
_____. 1903. Flora of the Southeastern United States. New York: by the author.
Smyth, B.B. 1898. Additions to the flora of Kansas. Trans. Kans. Acad. Sci. 15:60-73.
Sprengel, C. 1826. Caroli Linnaei Systemi Vegetabilium. 16th ed. Vol. 3. Gottingae: Dieterich.
_____. 1827. Caroli Linnaei Systema Vegetabilium. 16th ed. Vol.4. Pars II: Curae Posteriores. Gottingae: Dieterich.
Stapf, O. 1929. Index Londonensis. Oxford: The Clarendon Press.
Steudel, E.T. 1841. Nomenclator Botanicus. 2nd ed. Stuttgart: J.C. Cottae.
Stevens, O.A. 1946. Botanical visits to Forts Clark, Mandan and Union in North Dakota. Rhodora 48:98-103.
_____. 1946. Size, shape and number of Astragalus caryocarpus fruits. Rhodora 48:111.
_____. 1950. Handbook of North Dakota plants. Fargo: North Dakota Agricultural College.
Steyermark, J.A. 1959. Vegetational History of the Ozark Forest. Columbia, Missouri: University of Missouri.
Taubert, P. 1894. Leguminosae in Engler, A. Die Naturlichen Pflanzenfamilien. III. 3:70-388.
Tidestrom, I. 1925. Flora of Utah and Nevada. Contr. U.S. Nat. Herb. 25:1-665.
_____. 1937. Notes on Astragalus (Tournef.) L. Proc. Biol. Soc. Wash. 50:17-21.
_____ and Kittell, T.A. 1941. A Flora of Arizona and New Mexico. Washington: The Catholic University of America Press.
Tischler, G. 1938. Pflanzliche Chromosomenzahlen. IV. Tab. Biol. 16:162-218.
Tolstead, W.L. 1936. A Flora of Winneshiek and Allamakee Counties. Unpublished Master's Thesis. Ames, Iowa, Library: Iowa State University of Science and Technology.

Torrey, J. 1827. Some account of a collection of plants made during a journey to and from the Rocky Mountains in the summer of 1820, by Edwin P. James, M.D. Assistant Surgeon U.S. Army. Ann. Lyc. Nat. Hist. N.Y. 2:161-254.

_____ and A. Gray. 1838. Flora of North America. Vol.1. New York: Wiley and Putnam.

Trelease, S.F. and O.A. Beath. 1949. Selenium. Burlington, Vermont: The Champlain Printers.

Tschechow, W. 1930. Karyologisch-systematische Untersuchung des Tribus Galegeae, Fam. Leguminosae. Planta 9:673-680.

Turner, B.L. 1955. Chromosome numbers in the genus Sesbania (Leguminosae): Evidence for a conservative treatment. Rhodora 57:213-218.

Urban, I. 1919. Sertum antillanum. IX. Report. Spec. Nov. 16:132-151.

Vail, A.M. 1895. A revision of the North American species of the genus Cracca. Bull. Torrey Club 22:25-36.

Vauquelin, C. 1799. Sur le Robinia viscosa, et la substance résineuse qu'il produit. Bull. Soc. Philom. Paris. 1 (2):161-162.

Vilkomerson, H. 1943. Chromosome of Astragalus. Bull. Torrey Club 70:430-435.

Walter, Thomas. 1788. Flora Caroliniana. Londini: J. Fraser.

Watson, S. 1871. Botany in King, C. Report of the Geological exploration of the fortieth parallel. Vol.5. Washington: Government Printing Office.

_____. 1878, Bibliographical Index to North American Boatny. Washington: Published by the Smithsonian Institution.

_____. 1882. Contributions to American botany. XVIII. Proc. Am. Acad. 17:316-382.

_____. 1885. Contributions to American botany XIV. Proc. Am. Acad. 20:324-378.

_____. 1890. Contributions to American botany. Proc. Am. Acad. 25: 124-163.

_____ and W.H. Brewer. 1876. Botany. Polypetalae. Geol. Surv. Cal. 1:276.

Weaver, J.E. 1954. North American Prairie. Lincoln, Nebraska: Johnsen Publishing Co.

Wheeler, L.C. 1939. Astragalus versus Oxytropis. Leafl. West. Bot. 2:209-210.

Whitaker, T.W. 1934. A Karyo-systematic study of Robinia. Jour. Arnold Arb. 15:353-357.

Wildenow, C.L. 1803. Species Plantarum. Vol.3. Berloni: G.C. Nauk.

Winter, J.M. 1936. An analysis of the flowering plants of Nebraska. Nebr. Univ. Cons. Surv. Div. Bull. 13.

Wood, C.E. 1949. The American barbistyled species of Tephrosia (Leguminosae). Rhodora 51:193-302, 305-364, 369-384.

Wooten, E.O. and P.C. Standley.1913. Descriptions of new plants preliminary to a report on the Flora of New Mexico. Contr. U.S. Nat. Herb. 16:109-196.

_____ and _____. 1915. Flora of New Mexico. Contr. U.S. Nat. Herb. 19:9-794.

APPENDIX A

Synonyms and Excluded Species

The names presented in the following list consist of: (1) the synonyms of the species treated in the foregoing work, and (2) those names of species previously reported from the north-central states (and their synonyms), which are excluded from this treatment on one basis or another.

The names in the left column are the synonyms; those in the column on the right are the names of the species in the present treatment.

ARAGALLUS

A. aboriginum Greene	Oxytropis sericea Nutt.
A. albertinus Greene	Oxytropis campestris (L.) DC.
A. albiflorus A. Nels	Oxytropis sericea Nutt.
A. albiflorus var. condensatus A. Nels.	Oxytropis sericea Nutt.
A. angustatus Rydb.	Oxytropis lambertii Pursh
A. aven-nelsoni Lunell	Oxytropis lambertii Pursh
A. caudatus Greene	Oxytropis splendens Dougl.
A. cervinus Greene	Oxytropis campestris (L.) DC.
A. deflexus (Pall.) A. Hell.	Oxytropis deflexa (Pall.) DC.
A. dispar A. Nels.	Oxytropis campestris (L.) DC.
A. falcatus Greene	Oxytropis lambertii Pursh
A. formosus Greene	Oxytropis lambertii Pursh
A. galioides Greene	Oxytropis splendens Dougl.
A. invenustus Greene	Oxytropis sericea Nutt.
A. involutus A. Nels.	Oxytropis lambertii Pursh
A. lambertii (Pursh) Greene	Oxytropis lambertii Pursh
A. lambertii var. sericea (Nutt.) A. Nels.	Oxytropis sericea Nutt.
A. luteolus Greene	Oxytropis campestris (L.) DC.
A. macounii Greene	Oxytropis campestris (L.) DC.
A. majusculus Greene	Oxytropis sericea Nutt.
A. minor (A. Gray) Greene	Oxytropis multiceps Nutt.
A. monticola (A. Gray) Greene	Oxytropis campestris (L.) DC.
A. multiceps (Nutt.) A. Hell.	Oxytropis multiceps Nutt.
A. pinetorum A. Hell.	Oxytropis sericea Nutt.
A. pinetorum var. veganus Ckll.	Oxytropis sericea Nutt.
A. richardsonii (Hook.) Greene	Oxytropis splendens Dougl.
A. rigens Greene	Oxytropis lambertii Pursh
A. saximontanus A. Nels.	Oxytropis sericea Nutt.
A. saximontanus var. condensatus (A. Nels.) A. Nels.	Oxytropis sericea Nutt.
A. sericeus (Nutt.) Greene	Oxytropis sericea Nutt.
A. spicatus (Hook.) Rydb.	Rejected. This name was applied by Rydberg (1932) to specimens of Oxytropis sericea from the Black Hills region.

A. splendens (Dougl.) Greene	Oxytropis splendens Dougl.
A. veganus (Ckll.) Woot. & Standl.	Oxytropis sericea Nutt.
A. villosus Rydb.	Oxytropis campestris (L.) DC.
A. viscidus (Nutt.) Greene	Oxytropis viscida Nutt.
A. viscidulus Rydb.	Oxytropis viscida Nutt.
A. viscidula var. depressus Rydb.	Oxytropis viscida Nutt.

ASTRAGALUS

A. aboriginum (Richards.) Spreng.	Astragalus aboriginorum Richards.
A. aboriginum var. fastigorum M.E. Jones	Astragalus aboriginorum Richards.
A. aboriginum var. glabriusculus (Hook.) Rydb.	Astragalus aboriginorum Richards.
A. acerbus Sheld.	Astragalus tenellus Pursh
A. adsurgens sensu authors	Astragalus striatus Nutt.
A. adsurgens var. albiflorus Blankin.	Astragalus striatus Nutt.
A. adsurgens var. pauperculus Blankin.	Astragalus striatus Nutt.
A. adsurgens β robustior Hook.	Astragalus striatus Nutt.
A. agrestis var. polyspermus M.E. Jones	Astragalus agrestis Dougl.
A. albertinus (Greene) Tidestr.	Oxytropis campestris (L.) DC.
A. albiflorus (A. Nels.) Gand.	Oxytropis sericea Nutt.
A. albiflorus (A. Nels.) Tidestr.	Oxytropis sericea Nutt.
A. alpinus var. americanus (Hook.) Sheld.	Astragalus americanus (Hook.) Jones
A. ammolotus Greene	Astragalus lotiflorus Hook.
A. andinus (Nutt.) M.E. Jones	Astragalus alpinus L.
A. angustus M.E. Jones	Astragalus ceramicus Sheld.
A. angustus var. ceramicus (Sheld.) M.E. Jones	Astragalus ceramicus Sheld.
A. angustus var. imperfectus (Sheld.) M.E. Jones	Astragalus ceramicus Sheld.
A. angustus var. pictus M.E. Jones	Astragalus ceramicus Sheld.
A. astragalinus (DC.) Sheld.	Astragalus alpinus L.
A. batesii A. Nels.	Astragalus lotiflorus Hook.
A. bisontum Tidestr.	Oxytropis multiceps Nutt.
A. bisulcatus forma hedysariformis Gand.	Astragalus bisulcatus (Hook.) Gray
A. bodini Sheld.	Rejected. The writer has seen a single specimen of this species from Nebraska. It is far removed from the range of the species and possibly represented an adventive.
A. bourgovii A. Gray	Rejected. The range of this taxon lies to the west of the north-central states. Macbride (1922) reported the species for S. Dak., but the name was possibly applied to A. tenellus or other species.

A. caespitosus (Nutt.) A. Gray	Astragalus spatulatus Sheld.
A. campestris (Nutt.) A. Gray	Astragalus miser Dougl. (loc. cit.)
A. campestris var. hylophilus (Rydb.) M.E. Jones	Astragalus miser Dougl. (loc. cit.)
A. campestris L.	Oxytropis campestris (L.) DC.
A. canadensis var. brevidens (Gand.) Barneby	Astragalus canadensis L.
A. canadensis var. carolinianus (L.) M.E. Jones	Astragalus canadensis L.
A. canadensis var. longilobus Fassett	Astragalus canadensis L.
A. canadensis forma monticola Gand.	Astragalus canadensis L.
A. canadensis var. mortoni (Nutt.) S. Wats.	Astragalus canadensis L.
A. carnosus Pursh	Astragalus crassicarpus Nutt.
A. carolinianus L.	Astragalus canadensis L.
A. caryocarpus Ker	Astragalus crassicarpus Nutt.
A. ceramicus var. jonesii Sheld.	Astragalus ceramicus Sheld.
A. ceramicus var. imperfectus Sheld.	Astragalus ceramicus Sheld.
A. ceramicus var. longilobus (Pursh) Rydb.	Astragalus ceramicus Sheld.
A. chandonnetii Lunell	Astragalus striatus Nutt.
A. convallarius Greene	Astragalus miser Dougl. (loc. cit.) Rydberg applied this name to specimen no. 631 from west of Custer, South Dakota (1892) which is A. flexuosus.
A. convallarius var. hylophilus (Rydb.) Tidestr.	Astragalus miser Dougl. (loc. cit.)
A. crassicarpus var. pachycarpus	Astragalus plattensis Nutt.
A. crassicarpus var. trichocalyx (Nutt.) Barneby	Astragalus trichocalyx Nutt.
A. crassipes Fraser	Astragalus crassicarpus Nutt.
A. dasyglottis Nutt.	Astragalus agrestis Dougl.
A. decumbens (Nutt.) A. Gray	Astragalus miser Dougl. (loc. cit.)
A. debilis sensu Jones	Astragalus bodini Sheld.
A. deflexus Pall.	Oxytropis deflexa (Pall.) DC.
A. elatiocarpus Sheld.	Astragalus lotiflorus Hook.
A. fendleri A. Gray	Astragalus flexuosus (Hook.) Don
A. filifolius A. Gray	Astragalus ceramicus Sheld.
A. flexuosus Dougl.	Astragalus flexuosus (Hook.) Don
A. flexuosus var. elongatus (Hook.) M.E. Jones	Astragalus flexuosus (Hook.) Don
A. flexuosus var. fendleri	Astragalus flexuosus (Hook.) Don
A. flexuosus var. sierrae-blancae (Rydb.) Barneby	Astragalus flexuosus (Hook.) Don
A. foliolosus (A. Gray) Sheld.	Astragalus ceramicus Sheld.
A. forwoodii S. Wats.	Astragalus aboriginorum Richards.
A. frigidus sensu Gray	Astragalus americanus (Hook.) Jones

A. frigidus var. americanus (Hook.) S. Wats.	Astragalus americanus (Hook.) Jones
A. galegoides Nutt.	Astragalus racemosus Pursh
A. gaspensis (Fern. & Kels.) Tidestr.	Oxytropis viscida Nutt.
A. giganteus Sheld.	Astragalus alpinus L.
A. glabriusculus (Hook.) A. Gray	Astragalus aboriginorum Richards.
A. glabriusculus var. major A. Gray	Astragalus aboriginorum Richards.
A. glabriusculus var. spatiosus Sheld.	Astragalus aboriginorum Richards.
A. glycyphyllos L.	Rejected. The writer has seen one specimen of this species from our region. It was grown from seed reported to have been produced from adventive plants in Indiana.
A. goniatus Nutt.	Astragalus agrestis Dougl.
A. gracilentus var. fallax (S. Wats.) M.E. Jones	Astragalus flexuosus (Hook.) Don
A. gracilis β erectus Hook.	Astragalus gracilis Nutt.
A. gracilis var. parviflorus (Pursh) F.C. Gates	Astragalus gracilis Nutt.
A. grayanus Tidestr.	Oxytropis campestris (L.) DC.
A. haydenianus forma leiocarpa Gand.	Astragalus bisulcatus (Hook.) Gray
A. hylophilus (Rydb.) A. Nels.	Astragalus miser Dougl. (loc. cit.)
A. hylophilus var. oblongifolius (Rydb.) Macbr.	Astragalus miser Dougl. (loc. cit.)
A. hypoglottis sensu authors	Astragalus agrestis Dougl.
A. hypoglottis var. polyspermus T. & G.	Astragalus agrestis Dougl.
A. incurva (Rydb.) Abrams	Astragalus purshii Dougl.
A. kentrophyta A. Gray	Astragalus tegetarius S. Wats.
A. lambertii (Pursh) Spreng.	Oxytropis lambertii Pursh
A. laxmanni Nutt.	Astragalus striatus Nutt.
A. leptocarpus T. & G.	Rejected. This species was reported from Kansas (Rydberg, 1932), but no specimens have been seen from that state.
A. longifolius (Pursh) Rydb.	Astragalus ceramicus Sheld.
A. longifolius (Pursh) Gates	Astragalus ceramicus Sheld.
A. lotiflorus β brachypus A. Gray	Astragalus lotiflorus Hook.
A. lotiflorus var. cretaceus (Buckl.) Gates	Astragalus lotiflorus Hook.
A. lotiflorus var. elatiocarpus (Sheld.) Rydb.	Astragalus lotiflorus Hook.
A. lotiflorus var. nebraskensis Bates	Astragalus lotiflorus Hook.
A. lotiflorus α pedunculosus A. Gray	Astragalus lotiflorus Hook.
A. lotiflorus var. reverchoni (A. Gray) M.E. Jones	Astragalus lotiflorus Hook.
A. mazama (St. John) G.N. Jones	Oxytropis campestris (L.) DC.

A. melanocarpus Nutt.	Astragalus missouriensis Nutt.
A. mexicanus A. DC.	Rejected. This name was long used in place of A. trichocalyx Nutt. See discussion under that species.
A. mexicanus var. trichocalyx (Nutt.) Fern.	Astragalus trichocalyx Nutt.
A. microlobus A. Gray	Astragalus gracilis Nutt.
A. microphacos Cory	Astragalus gracilis Nutt.
A. miser Dougl.	Rejected. The writer has seen a single sheet of this species from the Black Hills of South Dakota. It was collected in 1895 by A. Pratt, but has not been collected since that time even though the region has been botanized by numerous collectors.
A. miser var. hylophilus (Rydb.) Barneby	Astragalus miser Dougl. (loc. cit.)
A. miser var. oblongifolius (Rydb.) Cronq.	Astragalus miser Dougl. (loc. cit.)
A. missouriensis β Nutt.	Astragalus missouriensis Nutt.
A. missouriensis forma leucophaea	Astragalus missouriensis Nutt.
A. missouriensis forma longipes Gand.	Astragalus missouriensis Nutt.
A. missouriensis forma microphylla Gand.	Astragalus missouriensis Nutt.
A. mitophyllus Kearney	Astragalus ceramicus Sheld.
A. montanus (Nutt.) M.E. Jones	Astragalus tegetarius S. Wats.
A. mortoni Nutt.	Astragalus canadensis L.
A. mortoni forma brevidens Gand.	Astragalus canadensis L.
A. mortoni forma rydbergii Gand.	Astragalus canadensis L.
A. multiflorus (Pursh) A. Gray	Astragalus tenellus Pursh
A. nebraskensis (Bates) Bates	Astragalus lotiflorus Hook.
A. neglectus (T. & G.) Sheld.	Astragalus cooperi A. Gray
A. neglectus forma limonius (Farwell) Fern.	Astragalus cooperi A. Gray
A. nigrescens (Hook.) A. Gray	Astragalus tenellus Pursh
A. nitidus Dougl.	Astragalus striatus Nutt.
A. nitidus var. robustior (Hook.) M.E. Jones	Astragalus striatus Nutt.
A. pachycarpus T. & G.	Astragalus plattensis Nutt.
A. pachystachys Rydb.	Astragalus canadensis L.
A. parviflorus (Pursh) MacMil.	Astragalus gracilis Nutt.
A. parviflorus var. microlobus (A. Gray) M.E. Jones	Astragalus gracilis Nutt.
A. parvifolius Nutt.	Astragalus gracilis Nutt.
A. pauciflorus Hook.	Astragalus vexilliflexus Sheld.
A. pectinatus var. platyphyllus M.E. Jones	Astragalus pectinatus Dougl.
A. pictus A. Gray	Astragalus ceramicus Sheld.
A. pictus var. angustus M.E. Jones	Astragalus ceramicus Sheld.

A. pictus var. filifolius (A. Gray) A. Gray	Astragalus ceramicus Sheld.
A. pictus var. foliolosus A. Gray	Astragalus ceramicus Sheld.
A. pictus var. magnus M. E. Jones	Astragalus ceramicus Sheld.
A. plattensis var. missouriensis	Astragalus tennesseensis A. Gray
A. plattensis var. tennesseensis (A. Gray) A. Gray	Astragalus tennesseensis A. Gray
A. prunifer Rydb.	Astragalus crassicarpus Nutt.
A. purshii var. incurvus (Rydb.) Jepson	Astragalus purshii Dougl.
A. purshii var. interior M.E. Jones	Astragalus purshii Dougl.
A. racemosus var. brevisetus M.E. Jones	Astragalus racemosus Pursh
A. racemosus var. longisetus M.E. Jones	Astragalus racemosus Pursh
A. racemosus var. treleasei C.L. Porter	Astragalus racemosus Pursh
A. racemosus var. typicus C.L. Porter	Astragalus racemosus Pursh
A. reverchoni A. Gray	Astragalus lotiflorus Pursh
A. richardsoni Sheld.	Astragalus aboriginorum Richards.
A. rydbergianus Tidestr.	Oxytropis campestris (L.) DC.
A. saximontanus (A. Nels.) Tidestr.	Oxytropis sericea Nutt.
A. scobatinatulus Sheld.	Rejected. Specimens (MO) bearing this name as annotated by Sheldon are A. racemosus Pursh.
A. setosus Pursh	Astragalus missouriensis Nutt.
A. shortianus Nutt.	Rejected. This species has been reported from Nebraska and So. Dakota, but no specimens of it have been seen from those states. Specimens bearing that name from Nebraska are Astragalus lotiflorus Hook.
A. simplex Tidestr.	Astragalus spatulatus Sheld.
A. simplicifolius var. caespitosus (Nutt.) M.E. Jones	Astragalus spatulatus Sheld.
A. simplicifolius var. spatulatus (Sheld.) M.E. Jones	Astragalus spatulatus Sheld.
A. similans Ckll.	Astragalus mollissimus Torr.
A. spatulatus var. simplex Tidestr.	Astragalus spatulatus Sheld.
A. spicatus Nutt.	Astragalus canadensis L.
A. splendens (Dougl.) Tidestr.	Oxytropis splendens Dougl.
A. splendens var. richardsonii (Hook.) Tidestr.	Oxytropis splendens Dougl.
A. striatus forma chandonnettii (Lunell) Moore	Astragalus striatus Nutt.
A. succulentus Richards.	Astragalus crassicarpus Nutt.
A. succulentus var. paysoni Kels.	Astragalus crassicarpus Nutt.
A. sulphurescens Rydb.	Astragalus striatus Nutt.
A. tenellus var. strigulosus (Rydb.) Herm.	Astragalus tenellus Pursh

A. tenellus forma acerbus (Sheld.) Macbr.	Astragalus tenellus Pursh
A. tenellus var. clementis (Rydb.) Macbr.	Astragalus tenellus Pursh
A. tenellus forma strigulosa (Rydb.) Macbr.	Astragalus tenellus Pursh
A. triphyllus Pursh	Astragalus gilviflorus Pursh
A. torreyi Rydb.	Astragalus canadensis L.
A. vaginatus sensu authors	Astragalus aboriginorum Richards.
A. virgultulus Sheld.	Astragalus agrestis Dougl.
A. viridis (Nutt.) Sheld.	Astragalus tegetarius S. Wats.
A. viscidus (Nutt.) Tidestr.	Oxytropis viscida Nutt.

ASPALATHUS

A. caragana (L.) Kuntze	Caragana arborescens Lam.
A. frutescens (L.) Kuntze	Caragana frutex (L.) Koch

ATELOPHRAGMA

A. aboriginum (Richards.) Rydb.	Astragalus aboriginorum Richards.
A. alpinum (L.) Rydb.	Astragalus alpinus L.
A. elegans (Hook.) Rydb.	Rejected. This species was reported from South Dakota by Rydberg (1932) but no specimens have been seen. It was probably applied to A. flexuosus or A. tenellus.
A. forwoodii (S. Wats.) Rydb.	Astragalus aboriginorum Richards.
A. glabriusculum (Hook.) Rydb.	Astragalus aboriginorum Richards.
A. wallowense Rydb.	Astragalus aboriginorum Richards.

BATIDOPHACA

B. cretacea (Buckl.) Rydb.	Astragalus lotiflorus Hook.
B. lotiflora (Hook.) Rydb.	Astragalus lotiflorus Hook.
B. nebraskensis (Bates) Rydb.	Astragalus lotiflorus Hook.

CARAGANA

C. arborescens var. typica Schneider	Caragana arborescens Lam.
C. arenaria Dippel	Caragana aurautiaca Koehne
C. argentea Lam.	Halimodendron halodendron (Pall.) Schneider
C. caragana Karsten	Caragana arborescens Lam.
C. cuneata Moench	Caragana frutex (L.) Koch
C. digitata Lam.	Caragana frutex (L.) Koch
C. frutescens (L.) DC.	Caragana frutex (L.) Koch
C. frutescens β angustifolia DC.	Caragana frutex (L.) Koch
C. frutescens var. grandiflora Rehder	Caragana frutex (L.) Koch

C. frutescens α latifolia DC.	Caragana frutex (L.) Koch
C. frutex var. grandiflora Koehne	Caragana frutex (L.) Koch
C. frutex var. macrantha Rehder	Caragana frutex (L.) Koch
C. frutex var. typica Schneider	Caragana frutex (L.) Koch
C. glomerata Hort.	Caragana frutex (L.) Koch
C. halodendron Hoff.	Halimodendron halodendron (Pall.) Schneider
C. inermis Moench	Caragana arborescens Lam.
C. microphylla Lam.	Rejected. The writer has seen only a single specimen of this species. It was collected from the Iowa State University campus prior to 1900.
C. parvifolia Hoff.	Caragana frutex (L.) Koch
C. pygmaea (L.) DC.	Rejected. The writer has seen only a single specimen of this species. It was collected from the Iowa State University campus prior to 1900.
C. pygmaea var. arenaria Maxim	Caragana aurantiaca Koehne
C. sibirica Medic.	Caragana arborescens Lam.

CNEMIDOPHACOS

C. pectinatus (Dougl.) Rydb.	Astragalus pectinatus (Hook.) Don

COLUTEA

C. astragalina (DC.) Poir.	Astragalus alpinus L.

CRACCA

C. holosericea Britt. & Baker	Tephrosia virginiana (L.) Pers.
C. leucosericea Rydb.	Tephrosia virginiana (L.) Pers.
C. virginiana L.	Tephrosia virginiana (L.) Pers.
C. virginiana var. holosericea (Nutt.) Vail	Tephrosia virginiana (L.) Pers.

CTENOPHYLLUM

C. pectinatum (Hook.) Rydb.	Astragalus pectinatus (Hook.) Don

CYTOSPORA

C. elatiocarpa (Sheld.) Lunell	Astragalus lotiflorus Hook.
C. lotiflora (Hook.) Lunell	Astragalus lotiflorus Hook.

DALEA

D. parviflora Pursh	Astragalus gracilis Nutt.

DARWINIA	
D. exaltata Raf.	Sesbania exaltata (Raf.) Cory
DIHOLCOS	
D. bisulcatus (Hook.) Rydb.	Astragalus bisulcatus (Hook.) Gray
D. decalvans (Gand.) Rydb.	Astragalus bisulcatus (Hook.) Gray
ERVUM	
E. multiflorum Pursh	Astragalus tenellus Pursh
GALEGA	
G. officinalis L.	Rejected. The writer has seen two sheets of this species. Both were collected prior to 1900. It might occur occasionally as a weed
G. virginiana L.	Tephrosia virginiana (L.) Pers.
G. virginica J.F. Gmel.	Tephrosia virginiana (L.) Pers.
GEOPRUMNON	
G. crassicarpus (Nutt.) Rydb.	Astragalus crassicarpus Nutt.
G. mexicanum sensu Rydb.	Astragalus trichocalyx Nutt.
G. pachycarpum (T. & G.) Rydb.	Astragalus plattensis Nutt.
G. plattense (Nutt.) Rydb.	Astragalus plattensis Nutt.
G. succulentum (Richards.) Rydb.	Astragalus crassicarpus Nutt.
G. tennesseensis (A. Gray) Rydb.	Astragalus tennesseensis A. Gray
G. trichocalyx (Nutt.) Rydb.	Astragalus trichocalyx Nutt.
GLYCYRRHIZA	
G. glutinosa Nutt.	Glycyrrhiza lepidota Pursh
G. lepidota var. glutinosa (Nutt.) S. Wats.	Glycyrrhiza lepidota Pursh
HALIMODENDRON	
H. argenteum (Lam.) Fisch.	Halimodendron halodendron (Pall.) Schneider
H. argenteum β subvirescens Fisch.	Halimodendron halodendron (Pall.) Schneider
H. argenteum α vulgare Fisch.	Halimodendron halodendron (Pall.) Schneider
H. cuspidatum Jaubert & Spach	Halimodendron halodendron (Pall.) Schneider
H. emarginatum Jaubert & Spach	Halimodendron halodendron (Pall.) Schneider

H. halodendron forma purpureum Schneider	Halimodendron halodendron (Pall.) Schneider
H. halodendron (Pall.) Voss	Halimodendron halodendron (Pall.) Schneider
H. speciosum Carr.	Halimodendron halodendron (Pall.) Schneider
H. subvirescens (Fisch.) Don	Halimodendron halodendron (Pall.) Schneider

HOLCOPHACOS

H. distortus (T. & G.) Rydb.	Astragalus distortus T. & G.

HOMALOBUS

H. aboriginorum (Richards.) Rydb.	Astragalus aboriginorum Richards.
H. aboriginum (Richards.) Rydb.	Astragalus aboriginorum Richards.
H. acerbus (Sheld.) Rydb.	Astragalus tenellus Pursh
H. brachycarpus Nutt.	Astragalus spatulatus Sheld.
H. caespitosus Nutt.	Astragalus spatulatus Sheld.
H. campestris Nutt.	Astragalus miser Dougl. pro parte (loc. cit.)
H. canescens Nutt.	Astragalus spatulatus Sheld.
H. clementis Rydb.	Astragalus tenellus Pursh
H. decumbens Nutt.	Astragalus miser Dougl. (loc. cit.)
H. dispar Nutt.	Astragalus tenellus Pursh
H. fendleri (A. Gray) Rydb.	Astragalus flexuosus (Hook.) Don
H. flexuosus (Hook.) Rydb.	Astragalus flexuosus (Hook.) Don
H. glabriusculus (Hook.) Rydb.	Astragalus aboriginorum Richards.
H. hylophilus Rydb.	Astragalus miser Dougl.(loc. cit.)
H. montanus (Nutt.) Britt.	Astragalus tegetarius S. Wats.
H. multiflorus (Pursh) T. & G.	Astragalus tenellus Pursh
H. nigrescens Nutt.	Astragalus tenellus Pursh
H. oblongifolius Rydb	Astragalus miser Dougl. (loc. cit.)
H. spatiosus (Sheld.) A. Hell.	Astragalus aboriginorum Richards.
H. stipitatus Rydb.	Astragalus tenellus Pursh
H. strigulosus Rydb.	Astragalus tenellus Pursh
H. tenellus (Pursh) Britt.	Astragalus tenellus Pursh

KENTROPHYTA

K. montana Nutt.	Astragalus tegetarius S. Wats.
K. viridis Nutt.	Astragalus tegetarius S. Wats.

LIQUIRITIA

Liquiritia lepidota Nutt.	Glycyrrhiza lepidota Pursh

MICROPHACOS

M. gracilis (Nutt.) Rydb.	Astragalus gracilis Nutt.

M. microlobus (A. Gray) Rydb.	Astragalus gracilis Nutt.
M. parviflorus (Pursh) Rydb.	Astragalus gracilis Nutt.

OROBUS

O. dispar Nutt.	Astragalus tenellus Pursh
O. longilobus Nutt.	Astragalus ceramicus Sheld.

OROPHACA

O. argophylla (Nutt.) Rydb.	Astragalus hyalinus M.E. Jones
O. caespitosa (Nutt.) Britt.	Astragalus gilviflorus Sheld.
O. sericea (Nutt.) Britt.	Astragalus sericoleucus A. Gray

OXYTROPIS

O. albertina (Greene) Rydb.	Oxytropis campestris (L.) DC.
O. albiflora (A. Nels.) K. Schum.	Oxytropis sericea Nutt.
O. angustata (Rydb.) A. Nels.	Oxytropis lambertii Pursh
O. aven-nelsoni (Lunell) A. Nels.	Oxytropis lambertii Pursh
O. bushii Gand.	Oxytropis lambertii Pursh
O. campestris var. chartacea (Fassett) Barneby	Oxytropis campestris (L.) DC.
O. campestris var. dispar (A. Nels.) Barneby	Oxytropis campestris (L.) DC.
O. campestris var. gracilis (A. Nels.) Barneby	Oxytropis campestris (L.) DC.
O. campestris var. viscida (Nutt.) S. Wats.	Oxytropis viscida Nutt.
O. cascadensis St. John	Oxytropis campestris (L.) DC.
O. caudata (Greene) K. Schum.	Oxytropis splendens Dougl.
O. chartacea Fassett	Oxytropis campestris (L.) DC.
O. condensata (A. Nels.) A. Nels.	Oxytropis sericea Nutt.
O. deflexa var. culminia Jeps.	Oxytropis deflexa (Pall.) DC.
O. deflexa var. sericea T. & G.	Oxytropis deflexa (Pall.) DC.
O. dispar (A. Nels.) K. Schum.	Oxytropis campestris (L.) DC.
O. falcata (Greene) A. Nels.	Oxytropis lambertii Pursh
O. gaspensis Fern. & Kels.	Oxytropis viscida Nutt.
O. gracilis (A. Nels.) K. Schum.	Oxytropis campestris (L.) DC.
O. hookeriana Nutt.	Oxytropis lambertii Pursh
O. involuta (A. Nels.) K. Schum.	Oxytropis lambertii Pursh
O. ixodes Butters and Abbe	Oxytropis viscida Nutt.
O. lambertii β Hook.	Oxytropis campestris (L.) DC.
O. lambertii γ T. & G.	Oxytropis lambertii Pursh
O. lambertii forma mixta Gand.	Oxytropis lambertii Pursh
O. lambertii var. ochroleuca A. Nels.	Oxytropis sericea Nutt.
O. lambertii var. sericea (Nutt.) A. Gray	Oxytropis sericea Nutt.
O. luteola (Greene) Piper & Beattie	Oxytropis campestris (L.) DC.
O. luteola (Greene) A. Nels.	Oxytropis campestris (L.) DC.

O. macounii (Greene) Rydb.	Rejected. The taxon represented by this name occurs to the north and west of our range. Rydberg (1932) cited this series as occurring in the north-central states. It was probably applied to O. sericea material.
O. mazama St. John	Oxytropis campestris (L.) DC.
O. minor (A. Gray) Ckll.	Oxytropis multiceps Nutt.
O. mollis Nutt.	Oxytropis viscida Nutt.
O. monticola A. Gray	Oxytropis campestris (L.) DC.
O. multiceps var. minor A. Gray	Oxytropis multiceps Nutt.
O. okanoganea St. John	Oxytropis campestris (L.) DC.
O. olympica St. John	Oxytropis campestris (L.) DC.
O. oxyphylla sensu Richards.	Oxytropis splendens Dougl.
O. pinetorus (A. Heil.) K. Schum.	Oxytropis sericea Nutt.
O. plattensis Nutt.	Oxytropis lambertii Pursh
O. retrorsa Fern.	Oxytropis deflexa (Pall.) DC.
O. retrosa var. sericea (T. & G.) Fern.	Oxytropis deflexa (Pall.) DC.
O. richardsonii (Hook.) K. Schum.	Oxytropis splendens Dougl.
O. richardsonii (Hook.) Woot. & Standl.	Oxytropis splendens Dougl.
O. saximontana (A. Nels.) A. Nels.	Oxytropis sericea Nutt.
O. splendens forma nelsoni Gand.	Oxytropis splendens Dougl.
O. splendens β richardsonii Hook.	Oxytropis splendens Dougl.
O. splendens forma strigosa Gand.	Oxytropis splendens Dougl.
O. splendens α vestita Hook.	Oxytropis splendens Dougl.
O. vegana (Ckll.) Woot. & Standl.	Oxytropis sericea Nutt.
O. villosus (Rydb.) K. Schum.	Oxytropis campestris (L.) DC.
O. viscidula (Rydb.) Tidestr.	Oxytropis viscida Nutt.

PHACA

P. aboriginorum Hook.	Astragalus aboriginorum Richards.
P. adsurgens sensu Piper	Astragalus striatus Nutt.
P. agrestis (Dougl.) Piper	Astragalus agrestis Dougl.
P. alpina (L.) Piper	Astragalus alpinus L.
P. americana (Hook.) Rydb.	Astragalus americanus (Hook.) Jones
P. andina Nutt.	Astragalus alpinus L.
P. argophylla Nutt.	Astragalus hyalinus M.E. Jones
P. astragalina DC.	Astragalus alpinus L.
P. bisulcata Hook.	Astragalus bisulcatus (Hook.) Gray
P. bodini (Sheld.) Rydb.	Astragalus bodini Sheld. (loc. cit.)
P. caespitosa Nutt.	Astragalus gilviflorus Sheld.
P. canadensis MacMil.	Astragalus canadensis L.
P. caryocarpa MacMil.	Astragalus crassicarpus Nutt.
P. cretacea Buckl.	Astragalus lotiflorus Hook.
P. elatiocarpa (Sheld.) Rydb.	Astragalus lotiflorus Hook.
P. elongata Hook.	Astragalus flexuosus (Hook.) Don

P. fendleri A. Gray	Astragalus flexuosus (Hook.) Don
P. flexuosa Hook.	Astragalus flexuosus (Hook.) Don
P. frigida var. americana Hook.	Astragalus americana (Hook.) Gray
P. glabriuscula Hook.	Astragalus aboriginorum Richards.
P. gracilis (Nutt.) MacMil.	Astragalus gracilis Nutt.
P. hypoglottis sensu MacMil.	Astragalus agrestis Dougl.
P. longifolia (Pursh) Nutt.	Astragalus ceramicus Sheld.
P. lotiflora (Hook.) T. & G.	Astragalus lotiflorus Hook.
P. mollissima Nutt.	Astragalus purshii Dougl.
P. neglecta T. & G.	Astragalus cooperi A. Gray
P. neglecta forma limonia Farwell	Astragalus cooperi A. Gray
P. parvifolia Nutt.	Rejected. This name was included as a synonym of P. parviflora Nutt. but the description does not fit P. parviflora Nutt. It is a synonym of A. gracilis Nutt.
P. pectinata Hook.	Astragalus pectinatus (Hook.) Don
P. picta A. Gray	Astragalus ceramicus Sheld.
P. plattensis (Nutt.) MacMil.	Astragalus plattensis Nutt.
P. purshii (Dougl.) Piper	Astragalus purshii Dougl.
P. reverchoni (A. Gray) Rydb.	Astragalus lotiflorus Hook.
P. sericea Nutt.	Astragalus sericoleucus A. Gray
P. triphylla (Pursh) Eaton and Wr.	Astragalus gilviflorus Sheld.
P. villosa James	Astragalus mollissimus Torr.
P. viridis (Nutt.) Britt.	Astragalus tegetarius S. Wats.

PHYSOCALYX

P. multiceps Nutt.	Oxytropis multiceps Nutt.

PHYSONDRA

P. dispar (Nutt.) Raf.	Astragalus tenellus Pursh
P. longifolia (Pursh) Raf.	Astragalus ceramicus Sheld.

PISOPHACA

P. elongata (Hook.) Rydb.	Astragalus flexuosus (Hook.) Don
P. flexuosus (Hook.) Rydb.	Astragalus flexuosus (Hook.) Don
P. ratonensis Rydb.	Astragalus flexuosus (Hook.) Don
P. sierrae-blancae Rydb.	Astragalus flexuosus (Hook.) Don

PSEUDOACACIA

P. halodendron (Pall.) Moench	Halimodendron halodendron (Pall.) Schneider
P. hispida (L.) Moench	Robinia hispida L.
P. odorata Moench	Robinia pseudoacacia L.

PSORALEA

P. longifolia Pursh	Astragalus ceramicus Sheld.
P. parviflora (Pursh) Poir.	Astragalus gracilis Nutt.

ROBINIA

R. acacia L.	Robinia pseudoacacia L.
R. breviloba Rydb.	Robinia neomexicana A. Gray
R. caragana L.	Caragana arborescens L.
R. fertilis Ashe	Robinia hispida L.
R. fragilis Salisb.	Robinia pseudoacacia L.
R. frutescens L.	Caragana frutex (L.) Koch
R. frutex L.	Caragana frutex (L.) Koch
R. glutinosa Sims	Robinia viscosa Vent.
R. grandiflora Hort.	Robinia hispida L.
R. hispida var. fertilis (Ashe) Clausen	Robinia hispida L.
R. hispida var. macrophylla DC.	Robinia hispida L.
R. hispida var. typica Schneider	Robinia hispida L.
R. hispida var. typica Clausen	Robinia hispida L.
R. hispida Michaux	Robinia hispida L.
R. hispida-rosea Mirb.	Robinia hispida L.
R. luxurians (Dieck) Schneider	Robinia neomexicana A. Gray
R. luxurians (Dieck) Rydb.	Robinia neomexicana A. Gray
R. macrophylla Schrad.	Robinia hispida L.
R. michauxii Sarg.	Robinia hispida L.
R. montana Bartr. ex Michx.	Robinia viscosa Vent.
R. montana Bartr. ex Pursh	Robinia hispida L.
R. neomexicana var. luxurians Dieck	Robinia neomexicana A. Gray
R. rosea Marsh.	Robinia hispida L.
R. rusbyi Woot. & Standl.	Robinia neomexicana A. Gray
R. subvelutina Rydb.	Robinia neomexicana A. Gray
R. unakae Ashe	Robinia hispida L.

SESBAN

S. exaltatus (Raf.) Rydb.	Sesbania exaltata (Raf.) Cory

SESBANIA

S. macrocarpa Muhl.	Sesbania exaltata (Raf.) Cory

SPIESIA

S. lambertii (Pursh) Kuntze	Oxytropis lambertii Pursh
S. lambertii var. sericea (Nutt.) Rydb.	Oxytropis sericea Nutt.
S. monticola (A. Gray) Kuntze	Oxytropis campestris (L.) DC.
S. multiceps (Nutt.) Kuntze	Oxytropis multiceps Nutt.
S. splendens (Dougl.) Kuntze	Oxytropis splendens Dougl.

S. viscida (Nutt.) Kuntze	Oxytropis viscida Nutt.

TEPHROSIA

T. holosericea Nutt.	Tephrosia virginiana (L.) Pers.
T. leucosericea (Rydb.) Cory	Tephrosia virginiana (L.) Pers.
T. virginiana var. holosericea (Nutt.) T. & G.	Tephrosia virginiana (L.) Pers.
T. virginiana var. leucosericea (Rydb.) Hermann	Tephrosia virginiana (L.) Pers.
T. virginica Bigel.	Tephrosia virginiana (L.) Pers.

TIUM

T. alpinum (L.) Rydb.	Astragalus alpinus L.
T. drummondii (Dougl.) Rydb.	Astragalus drummondii Dougl.
T. racemosum (Pursh) Rydb.	Astragalus racemosus Pursh
T. platycarpum Rydb.	Astragalus racemosus Pursh
T. scopulorum (Porter) Rydb.	Rejected. This species was reported for the north-central states by Rydberg (1932), but no specimens have been seen. The species occurs to the west of our region.

TRAGACANTHA

T. aboriginum (Richards.) Kuntze	Astragalus aboriginorum Richards.
T. alpina (L.) Kuntze	Astragalus alpinus L.
T. bisulcata (Hook.) Kuntze	Astragalus bisulcatus (Hook.) Gray
T. caespitosa (Nutt.) Kuntze	Astragalus spatulatus Sheld.
T. canadensis (L.) Kuntze	Astragalus canadensis L.
T. caryocarpa (Ker) Kuntze	Astragalus crassicarpus Nutt.
T. distorta (T. & G.) Kuntze	Astragalus distortus T. & G.
T. drummondii (Dougl.) Kuntze	Astragalus drummondii Dougl.
T. fendleri (A. Gray) Kuntze	Astragalus flexuosus (Hook.) Don
T. flexuosa (Hook.) Kuntze	Astragalus flexuosus (Hook.) Don
T. glabriuscula (Hook.) Kuntze	Astragalus aboriginorum Richards.
T. lotiflora (Hook.) Kuntze	Astragalus lotiflorus Hook.
T. microloba (A. Gray) Kuntze	Astragalus gracilis Nutt.
T. missouriensis (Nutt.) Kuntze	Astragalus missouriensis Nutt.
T. mollissima (Torr.) Kuntze	Astragalus mollissima Torr.
T. montana (Nutt.) Kuntze	Astragalus tegetarius S. Wats.
T. neglecta (T. & G.) Kuntze	Astragalus cooperi A. Gray
T. parviflora (Pursh) Kuntze	Astragalus gracilis Nutt.
T. pectinata (Hook.) Kuntze	Astragalus pectinatus (Hook.) Don
T. plattensis (Nutt.) Kuntze	Astragalus plattensis Nutt.
T. racemosa (Pursh) Kuntze	Astragalus racemosus Pursh
T. picta (A. Gray) Kuntze	Astragalus ceramicus Sheld.
T. purshii (Dougl.) Kuntze	Astragalus purshii Dougl.
T. sericea (Nutt.) Kuntze	Astragalus sericoleucus A. Gray

T. tenella (Pursh) Kuntze	Astragalus tenellus Pursh
T. triphylla (Pursh) Kuntze	Astragalus gilviflorus Sheld.

XYLOPHACOS

X. incurvus Rydb.	Astragalus purshii Dougl.
X. missouriensis (Nutt.) Rydb.	Astragalus purshii Dougl.
X. purshii (Dougl.) Rydb.	Astragalus purshii Dougl.

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OBSERVATIONS ON THE OCCURRENCE OF COPPER(I) FLUORIDE AS THE ACID-STABILIZED FLUOALUMINATE[1]

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ABSTRACT

Although copper(I) fluoride is unknown in the solid state there is some published evidence for its formation in solution in molten CuF_2. Since the addition of halide acids has been shown to stabilize lower oxidation states in similar systems, the Cu-CuF_2 reaction has been studied in the presence of AlF_3. The diamagnetism of the very inert, reddish-purple copper aluminum fluoride obtained at 996° has led to its formulation as a copper(I) fluoaluminate, possibly $Cu_3^{I}AlF_6$.

INTRODUCTION

It is commonly recognized that solid copper(I) fluoride is not thermodynamically stable. On the other hand, von Wartenberg (1) observed that CuF_2 apparently lost fluorine on fusion to give a solution of 8 to 10% CuF in CuF_2, and in the presence of copper metal the CuF concentration increased to 60 to 80%, with considerable depression of the freezing point. On solidification the presumed monofluoride usually disproportionated to metal and difluoride; however, in one instance a deep red, transparent solid was obtained that reverted to the original components before it could be examined structurally. In contrast, Ebert and Woitnek (2) had reported earlier that reaction of copper metal with a mixture of fluorine and chlorine gave, in addition to CuF_2, a layer next to the metal surface that was alleged to be CuF in the zinc sulfide structure. More recently, Crabtree, Lees and Little (3) were unable to find any evidence for the formation of CuF from a variety of reactions of the metal, copper(I) or copper(II) halides. They also noted that the lattice dimension reported for "CuF" (4.253 Å) was suspiciously close to that of Cu_2O (4.261 Å), a conceivable impurity on the metal employed by Ebert and Woitnek.

The apparent existence of CuF in a solution of CuF_2 but not in the solid state thus appears to be another example of the formation of the slightly-stable, lower halides that have been proposed to account for the apparent solution of a number of other metals in their molten halides (4). The instability of solid CuF (like aqueous Cu^+) can be attributed primarily to the much larger lattice (or hydration) energy of the dipositive state.

[1] Contribution No. 905. Work was performed in the Ames Laboratory of the U. S. Atomic Energy Commission.

Therefore, the formation of a larger anion through complexing of the halide ion by an appropriate acid should materially reduce the difference in lattice energies of the compounds in the two oxidation states and hence the tendency to disproportionate.[2] This approach has, for example, been recently employed in the isolation of solid cadmium(I) (5) and gallium(I) (6) tetrachloroaluminates. Accordingly, the reduction of CuF_2 by Cu has been investigated in the presence of the fluoride acid AlF_3, principally according to the stoichiometry required for the reaction

$$3\ Cu + 3\ CuF_2 + 2\ AlF_3 = 2\ Cu^{I}_{3}AlF_6.$$

EXPERIMENTAL

The starting materials were Baker's 99.99% Reagent copper turnings and anhydrous CuF_2 and AlF_3 obtained from A.D. MacKay, New York. The "CuF_2" as received had a pale green tint, and an X-ray powder pattern showed it to be mainly $Cu(OH)F \cdot CuF_2$ (8) together with small amounts of unidentified material and possibly copper chlorides. It was therefore hydrofluorinated in a copper boat in Inconel apparatus for 6 hrs. at 425 to 500°, after which the powder pattern data of the dull-white product agreed line for line with that reported for CuF_2 (3). The AlF_3 was also hydrofluorinated when the presence of HF was noted on opening the reaction containers. Its powder pattern agreed very well with that reported for AlF_3 (9). The fluorides were stored in evacuated containers.

The principal problem associated with the execution of the Cu-CuF_2-AlF reaction was a container sufficiently inert to the three components above 950°. Only copper itself was found to be suitable, and its melting point restricted reaction temperatures to those below 1084°. Graphite reduced CuF_2 to metal at 1150° while tantalum as well as tantalum coated with its carbide gave copper and the blue TaF_3 at 1100°. For use up to 1000-1050° a short length of hard copper tubing, 3/8 to 5/8" in diameter. was cleaned with HNO_3, pinched shut at one end, welded, and then loaded in the dry box with the weighed salts. After being crimped shut it was removed in a sample container and evacuated, and subsequently transferred to an argon- or helium-filled box where it was electrically welded. The sealed copper container was then enclosed in a stainless steel crucible with a welded lid. Failure of experiments was most commonly a result of rupture of the copper tube due to the internal pressure of inert gas, particularly when heated above 1050°. This was overcome to some extent by the use of 1 x 2" copper block in which a 3/8 x 1-7/8" hole had been drilled and, after being filled with the salts, was welded shut with a thick plug; this was in turn enclosed in a tightly-fitting tantalum crucible and a quartz tube.

[2] Compare the effect of increasing eize of the halide ion in isostructural series (7). The increase in the extent of reduction in the melt can also be interpreted in terms of the related decrease in the electrostatic and/or complexing interactions of the higher oxidation state with the anion.

RESULTS AND DISCUSSION

In spite of a considerable number of container failures, particularly above 1000°, a product was obtained from the reaction of CuF_2 with the metal in the presence of AlF_3 that had properties strongly suggestive of a copper(I) compound. After the reaction mixture had been heated at 996° for about 30 hours, small shiny, reddish-purple spheres were found on and near the copper turnings in the white matrix of unreacted salts. The product was found to be apparently unaffected by all common reagents, hot as well as cold, and, although an analysis was therefore not attempted, major amounts of copper and aluminum were found upon spectrographic examination. The most powerful evidence that the product was a copper(I) compound was its diamagnetism, since all known copper (II) compounds are paramagnetic. In fact, a ruby-red, paramagnetic product, readily soluble in dilute acids, was obtained from the reaction of CuF_2 and excess AlF_3 without reduction. The X-ray powder pattern of the copper(I) compound[3] was also unique, except for possibly a very minor AlF_3 content, and differed from known alkali metal fluoaluminates (9, 10). Although the evidence supports only a copper(I) fluoaluminate of the general type $Cu^{I}_{x}AlF_{3+x}$, its formulation as Cu_3AlF_6 might be favored both by the similarity in radius of Cu^+ to Na^+, where $NaAlF_4$[4] and Na_2AlF_5 are unknown (11), and by the unfavorable effect of small, acidic cations on complex anion structures (13). Reaction was not observed with mole ratios of CuF_2 and AlF_3 other than that corresponding to the formation of AlF_6^{-3}.

After the above work had been completed it came to the attention of the authors that Sharp and Sharpe (14) had recently prepared toluene solutions of copper(I) fluoborate and hexafluophosphate, among others, by reduction of the corresponding silver salts with copper metal; they noted only disproportionation when the solvent was evaporated. As this effectively demonstrates the existence of copper(I) fluoride stabilized with other acids, albeit only in a weakly coordinating solvent, no further investigation of the fluoaluminates has been undertaken.

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[3] The principal distances obtained, with relative intensities in parentheses, were: 5.71(2), 5.57(3), 2.84(2), 2.81(7), 2.44(5), 2.37(10), 2.13(4), 1.877(4), 1.726(3), 1.605(7), 1.428(5), 1.410(3), 1.397(5).

[4] $NaAlF_4$ reportedly forms on rapid condensation of gaseous mixtures of NaF and AlF_3; however, the compound is unstable above 470° (or less) and does not appear in the phase diagram (12).

REFERENCES

1. Von Wartenberg, H. 1939. Z. anorg. allgem. Chem. 241:381.
2. Ebert, F. and H. Woitnek. 1933. Z. anorg. allgem. Chem. 210:269.
3. Crabtree, J.M., C.S. Lees, and K. Little. 1955. Jour. Inorg. Nucl. Chem. 1:213.
4. Corbett, J.D., S. von Winbush and F.C. Albers. 1957. Jour. Am. Chem. Soc. 79:3020.
5. _____ and R.K. McMullan. 1956. Jour. Am. Chem. Soc. 78:2906; J.D. Corbett, W.J. Burkhard and L.F. Druding, to be published.
6. McMullan, R.K. and J.D. Corbett. 1958. Jour. Am. Chem. Soc. 80:4761.
7. Van Arkel, A. 1949. Research 2:307.
8. Wheeler, C. and H. Haendler. 1954. Jour. Am. Chem. Soc. 76:263.
9. X-Ray Powder Data File, G.W. Brindley, Ed. 1959. Am. Soc. for Testing Materials, Philadelphia 3, Penna.
10. Brosset, C. 1938. Z. anorg. allgem. Chem. 283:201.
11. Cowley, J. and R. Scott. 1947. Jour. Am. Chem. Soc. 69:2596.
12. Howard, E.H. 1954. Jour. Am. Chem. Soc. 76:2041.
13. Flood, H. and T. Forland. 1947. Acta Chem. Scand. 1:592, 781.
14. Sharp, D. and A. Sharpe. 1956. Jour. Chem. Soc. 1858.

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SOME NOTES ON THE USE OF ROSA LAXA AS A SOURCE OF HARDINESS IN ROSE BREEDING[1]

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The major objective of rose breeders since the introduction into Europe in 1792 of the everblooming clones of the southern Chinese R. chinensis-R. gigantea complex has been the development of everblooming roses capable of surviving the coldest winters without protection. To further this goal, various rose species indigenous to the colder areas of the northern hemisphere have been combined with the everblooming clones. The current classes of everblooming garden roses are the result.

Although hardier than their everblooming ancestors, current garden roses are not dependably winter-hardy in many sections of the country. Little improvement in this respect can be expected within existing rose groups, for the ancestral species do not contain factors for superior winter hardiness. The only recourse is the introduction into breeding programs of one or more rose species carrying factors for superior hardiness.

The tetraploid species, Rosa laxa, Retzius (4), which is indigenous to the dry steppes of central Siberia, is such a species. It has never been a popular garden subject, for it is lacking in many of the qualities demanded of ornamentals. The plants of R. laxa which are currently available in the United States have been derived by seed and asexual propagation from plants grown from seed collected by Hansen in the Altai region of Siberia in 1913. This collection was given the name 'Semi' to distinguish it from earlier ones (3). This species is closely allied to R. cinnamomea and is included in the section Cinnamomeae. The name 'laxa' has been given erroneously to two other roses; one, a form of R. blanda and the other, a form of R. canina.

Seedling populations of R. laxa show variation in plant height, degree of armature, presence and degree of pubescence on the foliage, and degree of remontance. Plant habit, flower color, foliage retention, disease tolerance, and hardiness are remarkably constant characteristics. The plants are very hardy, having survived, without protection of any kind, -30°F without injury (1). The plants are erect, vigorous, and range in height from four to eight feet. The young canes are yellow-green, changing to greenish-yellow with maturity. Bristles are plentiful on the basal portion of the canes. The flowering canes are free of bristles

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but have paired, curved infrastipular spines. Suckering is moderate. The large foliage is moderately susceptible to rose blackspot and tolerant of powdery mildew. However, the foliage matures and is lost early so that the plants are bare, except for the immature growth at the tips of the canes, by mid-September. The two-inch, five-petalled, white flowers are borne in clusters of five, terminally on lateral shoots arising from canes of the previous season's growth. Flowers later in the season are borne on secondary laterals from stems bearing the June bloom. Although the plants flower profusely in late May and continue intermittently until frost, the small size of the flower and flower cluster contribute to the effect of sparseness.

Beginning with 1951, the clone listed in the literature as R. laxa Morden (2) was used in combination with garden roses of several classes, both June-blooming and everblooming. Although Skinner (3) has used R. laxa in combination with R. spinosissima to produce June-blooming shrub roses, no reports have been found in the literature on the extensive use of this species in rose breeding to develop everblooming garden roses. It is thought that observations on the characteristics of these F_1 and later hybrids and a comparison with both the garden rose and species parents may be of interest to other breeders.

Although R. laxa has been used as a parent in crosses in most of the years since 1951 in combination with other species, shrubs, and everblooming garden roses, this report is based upon crosses in which the Hybrid Tea cultivars 'Crimson Glory,' 'Mrs. Sam McGredy,' and 'Happiness' and a June-blooming shrub rose, 'Josef Rothmund,' a derivative of R. eglanteria (5), were used as seed parents. Like most of the species comprising the Cinnamomeae, R. laxa does not set seed readily with foreign pollen.

Plant and Flower Characteristics of the F_1 Hybrids

The F_1 seedlings resulting from the use of R. laxa pollen on the cultivars 'Crimson Glory,' 'Mrs. Sam McGredy,' 'Happiness,' and 'Josef Rothmund' have, with the exception of certain seedlings, been fully hardy in normal Iowa winters. Some nonhardy seedlings coming from one of the Hybrid Tea cultivars, 'Crimson Glory,' display none of the characteristics of the pollen parent, leading to the assumption that they resulted from accidental self-pollination of the seed parent. The cultivars of the Hybrid Tea class survive winters here only with careful winter-protection. 'Josef Rothmund' is half-hardy, retaining sufficient wood in most winters, without protection, to permit a limited flowering the following June (1). Resistance to high summer temperatures and drought have been satisfactory. The plants, as well as both parents, continue normal growth and retain their foliage through periods of deficient rainfall.

The development of disease tolerance has received considerable attention in the breeding program and is perhaps the greatest problem, next to hardiness, in areas where roses are grown. Most garden roses, including the ones used as seed parents in these crosses, are very susceptible to blackspot and powdery mildew, R. laxa is highly resistant to powdery mildew and is moderately susceptible to the strains of blackspot

peculiar to the Ames area. The F_1's have proved to be no more resistant to blackspot infection than the garden rose parents. Powdery mildew has not been noticed on the F_1's, even when conditions resulting in heavy infection on plants growing in adjacent rows are present.

Premature defoliation is a serious fault in R. laxa, which limits its use as an ornamental to those areas with a short growing season. The foliage of the F_1's is intermediate in appearance to that of the parents. With the exception of a few seedlings, the foliage is lost as early as that of the species parent. In the case of the few individuals which retain their foliage until frost, the leaves take on autumnal coloring in bright scarlet, maroon and orange tones. This characteristic has not been noted in either parent.

In plant growth, the F_1's are vigorous to very vigorous, more closely approaching their R. laxa parent in this respect. In growth habit and height they are intermediate to the parents with no individuals closely approaching either parent.

Time of bloom is late May and early June, as in the R. laxa parent. Neither the everblooming habit of the Hybrid Tea parent nor the remontant bloom habit of R. laxa has been recovered in the F_1's.

In the crosses with the Hybrid Teas, the flowers are intermediate to the parents in size, with none as small as those of the R. laxa parent or as large as the flowers of the Hybrid Tea parent. There is a complete range in petalage from single flowers with five petals to very double blooms having more than 75 petals and petaloids. Flower form and texture are usually poor. Malformed pistils and stamens are the rule. Pollen, when it can be collected, is viable and is instrumental in obtaining a seed set on a wide range of garden rose cultivars.

The cross with 'Josef Rothmund' produced, with one exception, F_1 progeny whose appearance can be best described as dwarf forms of R. laxa. The influence of 'Josef Rothmund' is evident in the reduced size of the plant, freedom from suckering, smaller leaf size, and the presence of red pigmentation in the immature foliage and stems. The primocanes are sparsely bristly at the base. The infrastipular spines on the floracanes are lacking. Those spines which are present are straight or slightly hooked, as in Rosa laxa. Although it has the plant habit of the rest of the F_1's of this cross, the exception mentioned above has the light salmon-pink, double flowers of 'Josef Rothmund.' This seedling was selected for further use in breeding.

Plant and Flower Characteristics of Advanced R. laxa Hybrids

Several selections were made from the F_1 hybrids of the R. laxa-garden rose combinations. These were used in further breeding with garden roses. The progeny obtained by backcrossing two of the F_1 selections to garden roses are typical of the results obtained from the F_1-garden rose backcrosses and are described below. The first is derived from the cross of 'Crimson Glory' x R. laxa and is typical of those F_1's coming from crosses with the Hybrid Teas. Growth is vigorous and erect. The green canes are thickly covered with spines at the base and relatively free of spines on the flowering stems, as in the R. laxa parent.

The foliage is large, leathery, free from powdery mildew and very susceptible to blackspot. Armature is intermediate in placement and type to that of the parents. The flowers are pale rose-pink, moderately double, with deformed pistils and stamens, but viable pollen is produced occasionally. The flowering period lasts for six weeks in late May and June. The second selection is the one referred to previously in the discussion of the F_1 progeny of 'Josef Rothmund' and R. laxa. The progenies of these two selections back-crossed to garden roses are typical of those which result from back-crossing other F_1's from crosses of this type to garden roses.

Pollen from the 'Crimson Glory'-R. laxa seedling was effective in producing viable seed on a wide range of cultivars of the Hybrid Tea, Floribunda, and Grandiflora garden classes. The seedlings segregate into two sharply defined groups of approximately equal numbers. One group bears a pronounced resemblance to R. laxa in growth habit, foliage and prickle characteristics. The flowers, which are borne only in June, are single, two to three inches in diameter, and are in the lighter tones of pink, salmon, and yellow. All the plants in this group are as hardy as the species parent. The plants of the second group resemble the garden rose parent in floral and foliage characteristics. The plants are June-blooming; the everblooming habit of the Hybrid Tea and the remontance of R. laxa being absent. All plants of this group winter-killed during the winter of 1958-59, even though they had been given winter protection. All the seedlings retained the freedom from powdery mildew and the susceptibility to blackspot of the 'Crimson Glory'-R. laxa parent.

The 'Josef Rothmund'-R. laxa seedling produces abundant pollen, which is effective in producing seed pods on a wide range or garden and shrub roses. Of chief interest are combinations involving everblooming roses of the Hybrid Tea and Floribunda roses classes. The Hybrid Tea cultivars 'Crimson Glory,' 'Happiness,' 'Dean Collins,' 'Pink Princess,' and 'Lady Alice Stanley' were the principal seed parents involved. The Floribunda cultivars used as seed parents were 'Kordes' Harmonie,' 'Florence Mary Morse,' 'Feuermeer,' and 'Herrenhausen.' The first three are derivatives of R. eglanteria; the last, a Floribunda of the European type.

The seedlings resulting from combining this selection with the Hybrid Teas bear a strong resemblance to that group in appearance of foliage and floral characters. The flowers are large, ranging from four to five inches in diameter, and double with 25-35 petals. Dark colors are absent, in spite of the use of the cultivars 'Dean Collins,' 'Happiness' and 'Crimson Glory' which are noted for producing progeny in the dark pink and red color range. The effect of the species parent can be seen in the semi-folded leaflets, the placement and type of armature, and early defoliation. Although the plants range in hardiness from those which kill back to within six inches of the ground to those which lose only the immature tips of the canes, they are hardier than the Hybrid Tea parent. Plant height ranges from 4 to 6 feet. Remontant segregates appear in a ratio of 8 June-flowering plants to 1 remontant.

The progeny from the Floribunda combinations are vigorous shrubs ranging in height from four to six feet. The abundant foliage is large and is held until late in the season. There is the same level of resistance

to foliar diseases noted in the F_1 populations. The flowers, ranging from five to 45 petals in the lighter tints of pink, apricot, salmon, and yellow, vary in size from $3\frac{1}{2}$ to 5 inches and are borne in clusters of five to seven. The plants continue growth until late in the season, resulting in tip killing of the immature wood. While the general appearance of the plants is that of the Floribunda parents, R. laxa influence is evident in the location and shape of the spines, shape of leaflets and stipules, and superior hardiness. Remontant segregates, which retain the basic hardiness of the pollen parent, are obtained from the garden rose-'Josef Rothmund'-R. laxa progeny.

It is believed that the most valuable characteristics of R. laxa which appear to be transmitted to its progenies in crosses with selected garden rose varieties are (a) cold-hardiness, (b) resistance to powdery mildew, and (c) adaptability to areas of high temperatures and humidities and low summer rainfall. It should be possible to incorporate these features of R. laxa into our everblooming garden roses and develop cultivars adapted to culture in those areas where most cultivars now in existence can be grown only with careful attention to winter protection.

LITERATURE CITED

1. Buck, G.J. 1959. Cold hardiness of rose varieties. American Rose Annual 44:133-138.
2. _____. 1953. Shrub roses. American Rose Annual 38:168-172.
3. Skinner, F.L. 1956. New approach to the breeding of hardy roses. American Rose Annual 41:123-125.
4. South Dakota Agricultural Experiment Station. 1929. Hardy roses for South Dakota. Bulletin 240.
5. Von Rathlef, H. 1937. Die Rose als Objeckt der Zuchtung. Gustav Fischer, Jena, Germany. 82 pp.
6. Wylie, Ann. Dec. 1954; Jan. Feb. 1955. The history of garden roses. Jour. Roy. Hort. Soc. 79:55-571, 80:8-24, 77-87.

PUBLICATIONS OF MEMBERS OF THE STAFF OF THE IOWA STATE UNIVERSITY FOR THE ACADEMIC YEAR 1959-60

Certain summaries and indices are of interest in a survey of the publications of members of the staff of an educational and research institution such as the Iowa State University. The publications are listed in alphabetic order under the names of the senior authors. Junior authors are also listed alphabetically with cross reference to senior author.

SUMMARY

Number of individuals listed	792
Number of publications	787
Number of publications with single author	338
Number of publications with joint authorship	449
Number of departments or fields represented in publications	49
Number of individuals who serve as editors or on the editorial staff of one or more scientific or technical periodicals	46

Individuals thus serving are: Aronoff; Ayres; Black; Buchanan; Buehler; Burchinal; Carlander; Dahm; Diehl; Duncan; Eppright; Fassel; Gilman; Grabe; Heath; Heer; Hofstad; Hoyt; Kempthorne; Kenkel; Kirkham; Kuetemeyer; Larson; Lockhart; Loomis; Mahlstede; Melampy; Nordskog; Packer; Pederson; Phillips, Richard; Pierre; Roth; Rothenbuhler; Royer; Rundle; Stahl; Staniforth; Swanson; Thompson, Leon E.; Tintner; Weber; Weller; Werkman.

INDEX TO PUBLICATIONS BY DEPARTMENTS OR FIELDS

The numbers which follow the names of the departments refer to the index number of the alphabetic list by authors.

Zoology and Entomology Con't. -
368, 369, 376, 390, 393, 424, 426, 444
464, 491, 496, 502, 507, 524, 527, 528
529, 537, 544, 545, 579, 580, 581, 584
589, 597, 604, 630, 632, 675, 693, 717
718, 739, 757, 758, 759.

INDEX BY RESEARCH INSTITUTES AND EXTENSION SERVICES

AUTHORS AND PUBLICATIONS

1. Acker, D.C., D.V. Catron, and V.W. Hays. Lysine and methionine supplementation of corn-soybean oil meal rations for pigs in drylot. Jour. Anim. Sci. 18:1053-1058. 1959.
2. _____, J.V. Whiteman, Eula Morris, Ruth Leverton, Robert MacVicar, and L.S. Pope. Some effects of stilbestrol and related hormones on feedlot performance and carcass merit of fed lambs. Jour. Anim. Sci. 18:1255-1263. 1959.
3. Acker, R.F. and S.E. Hartsell. Fleming's lysozyme. Scientific Amer. 202:132-142. 1960.
4. _____, L.Y. Quinn, W.R. Lockhart, and P.A. Hartman. A simple freeze-drying apparatus. Amer. Jour. Med. Tech. 26:84-85. 1960.

Ackerman, J., joint author. See under Heady.

5. Aikman, J.M. and E.P. Sylwester. Effects of time and method of treatment on tree kill and bluegrass recovery. Iowa Acad. Sci. Proc. 66:103-112. 1959.

_____, joint author. See under Hendrickson.

Addis, L.K., joint author. See under Monroe.

Albers, F.C., joint author. See under Corbett.

6. Aldinger, S.M., V.C. Speer, V.W. Hays, and D.V. Catron. Effect of saccharin on consumption of starter rations by baby pigs. Jour. Anim. Sci. 18:1350-1355. 1959.

Allen, R.S., joint author. See under Hartman.

7. Almfeldt, M.W. and Carl A. Arnbal. Engineering graphics problem book 2. 66 pp. Wm. C. Brown Book Co., Dubuque, Iowa. 1959.

Alsup, B., joint author. See under Burrill.

8. Altman, L.B. and L.F. Charity. Demand studies on farm electric service. Agric. Engr. 41(4):237-240. 1960.

_____, joint author. See under Charity.

Altpeter, L.L., joint author. See under Fassel.

9. Anderson, Dale Arden. Effect of acceleration on the pressure distribution of a slender body of revolution. Sandia Corp. Tech. Memo SCTM229-59 (51), 30 pp. 1959.

Anderson, E.W., joint author. See under Serovy.

Anderson, L.L., joint author. See under Day.

10. Ansari, A.Q. and W.E. Loomis. Leaf temperatures. Amer. Jour. Bot. 46:713-717. 1959.

Arbogast, C.L., joint author. See under Smith, J.F.

11. Armstrong, R.E. Farm custom rate guide for 1960. Iowa Farm Sci. 14(7):423-424. 1960.

Arnbal, C.A., joint author. See under Almfeldt, Rising.

Arnold, F., joint author. See under Barker.

12. Arnold, Lionel K. Increase industrial use for farm products? Iowa Farm Sci. 14(9):11-12. 1960.
13. _____. Use surplus corn for alcohol? Iowa Farm Sci. 14(8):15-16. 1960.
14. _____. What possibilities for oil crops? Iowa Farm Sci. 14(1):6-8. 1959.
15. _____ and R. Basu Roy Choudhury. The determination of the neutral oil content of crude vegetable oils. Jour. Amer. Oil Chem. Soc. 37:87-88. 1960.
16. Aronoff, S. Kinetic models of aconitace action. Arch. Biochem. and Biophys. 88:302. 1960.

_____, joint author. See under Gage.

_____, Associate Editor. Plant Physiology.

Arthur, I.W., joint author. See under Holmes.

17. Assimacopoulos, B.M., Robert F. Warner, and Carl E. Ekberg, Jr. High speed fatigue tests on small specimens of plain concrete. Jour. Prestressed Concrete Inst. 4(2):53-70. 1959.
18. Atkins, R.E. Sorghums, section in Crops Management of Midwest Farm Handbook. 5th ed. pp. 240-242. 1960.
19. _____. Barley, wheat and flax, sections in Midwest Farm Handbook. 5th ed. pp. 244-246. 1960.

_____, joint author. See under Carlson.

_____, Consulting Editor. Agronomy Journal.

20. Atoji, Masao and Ronald C. Medrud. Structures of calcium dicarbide and uranium dicarbide by neutron diffraction. Jour. Chem. Physics 31:332-337. 1959.
21. _____ and R.E. Rundle. Neutron diffraction study on sodium tungsten bronzes Na_xWO_3 ($x = 0.9 \sim 0.6$). Jour. Chem. Physics 32:627-628. 1960.
22. _____, J.E. Schirber and C.A. Swenson. Crystal structure of β-Hg. Jour. Chem. Physics 31:1628-1629. 1959.
23. _____ and D.E. Williams. Deuterium positions in lanthanum deuteroxide by neutron diffraction. Jour. Chem. Physics 31:329-331. 1959.
24. Ayres, John C. Temperature relationships and some other characteristics of the microbial flora developing on refrigerated beef. Food Research 25:1-18. 1960.
25. _____. Effect of sanitation, packaging and antibiotics on the microbial spoilage of commercially processed poultry. Iowa State Jour. Sci. 34:27-46. 1959.
26. _____. The antifungal antibiotic A-5283, A-5288, myprozine, pimaricin. Food Technology 13:420. 1959.
27. _____. Use of coating materials or film impregnated with chlortetracycline to enhance color and storage life of fresh beef. Food Technology 13: 512-515. 1959.

_____, joint author. See under Card, Escanilla, Walker.

_____, Associate Editor. Applied Microbiology.

29. Ballantyne, Charles R. and R.A. Wilcox. A guide to a step by step approach in watershed development. Iowa Agr. and H. Ec. Ext. Serv. Pamphlet No. 265. 8 pp. 1960.
30. Balloun, S.L., W.J. Owings, J.L. Sell and R.E. Phillips. Energy and protein requirements for turkey starting diets. Poultry Sci. 38:1328-1340. 1959.

_____, joint author. See under Owings.

Bancroft, T.A., joint author. See under Richards.

31. Banks, Charles V. and R.I. Bystroff. Stability orders in transition metal-1,10-phenanthroline complexes. Jour. Amer. Chem. Soc. 81:6153-6158. 1959.
32. _____ and John J. Richard. The determination of vic-dioximes. Talanta 2:235-238. 1959.
33. _____ and Rajendra S. Singh. Composition and stability of 5-sulfosalicylate complexes of beryllium and copper. Jour. Amer. Chem. Soc. 81:6159-6163. 1959.
34. _____ and Ronnie V. Smith. Spectrophotometric determination of palladium using 4-methyl-1,2-cyclohexanedionedioxime. Anal. Chim. Acta 21: 308-311. 1959.

35. Barker, Randolph and Earl O. Heady. Economy of innovations in dairy farming to increase resource returns. Iowa Agric. and H. Ec. Exp. Sta. Res. Bull. 478. 1960.
36. _____, Earl O. Heady and Floyd Arnold. What milking system for your herd? Iowa Farm Sci. 14(2):10-12. 1959.
37. Barnes, K.K., C.W. Bockhop, and H.E. McLeod. Similitude in studies of tillage implement forces. Agric. Engr. 41:32-37, 42. 1960.
_____, joint author. See under Schaller.
38. Barnes, R.G. and S.L. Segel. Pure nuclear quadruple resonances in paramagnetic iron-group halides. Phys. Rev. Letters 3:462-464. 1959.
39. Barron, G.L. and R.W. Lichtwardt. Quantitative estimations of the fungi associated with deterioration of stored corn in Iowa. Iowa State Jour. Sci. 34:147-155. 1959.
_____, joint author. See under Lichtwardt.
40. Bartell, L.S. Effect of specimen delocalization in electron diffraction studies on gas molecules. Jour. Appl. Phys. 31:252-254. 1960.
41. _____. On the effects of intramolecular van der Waals forces. Jour. Chem. Phys. 32:827-831. 1960.
42. _____. On the length of the carbon-carbon single bond. Jour. Amer. Chem. Soc. 81:3497-3498. 1959.
43. _____. An electron diffraction study of monomethyl- and dimethylphosphine. Jour. Chem. Phys. 32:832-834. 1960.
44. _____. Secondary isotype effects and mass-sensitive amplitudes of vibration. Tetrahedron Letters 6:13-16. 1960.
45. _____ and R.A. Bonham. Structure of isobutylene. Jour. Chem. Phys. 32:824-826. 1960.
46. _____ and R.A. Bonham. Molecular structure of ethylene. Jour. Chem. Phys. 31:400-404. 1959.
47. _____ and L.O. Brockway. Electron diffraction study of trimethylphosphine. Jour. Chem. Phys. 32:512-515. 1960.
48. _____ and R.C. Hirst. An electron diffraction study of the structure of phosphine. Jour. Chem. Phys. 31:449-451. 1959.
49. _____ and R.J. Ruch. The wetting of incomplete monomolecular layers. II. Correlation with molecular size and shape. Jour. Phys. Chem. 63:1045-1049. 1959.
_____, joint author. See under Bonham, Ruch.
Bartholomew, W.V., joint author. See under Sabey.
Barton, T.A., joint author. See under Rush.
50. Bass, L.N. Comparison of germination percentages obtained for Highland bentgrass seed tested at different temperature alternations. Proc. Assoc. Off. Seed Anal. 49:73-76. 1959.
51. _____. Packaging and storage of Kentucky bluegrass and creeping red fescue seed. Proc. Assoc. Off. Seed Anal. 49:173-181. 1959.
52. _____. Uniformity trial of a 15-30°C walk-in type germinator. Proc. Assoc. Off. Seed Anal. 49:119-121. 1959.
53. _____. Bluegrass blending. Proc. Assoc. Off. Seed Anal. 49:63-67. 1959.
_____, joint author. See under Isely.
Bates, D.S., joint author. See under Baugh.
54. Baugh, C.L., G.W. Claus, and C.H. Werkman. Heterotrophic fixation of carbon dioxide by extracts of Nocardia corallina. Arch. Biochem. and Biophys. 86:255-259. 1960.
55. _____, T. Myoda, D.S. Bates, and C.H. Werkman. Mechanisms of carbon dioxide fixation by cell-free extracts of heterotrophic and photosynthetic bacteria. Iowa State Jour. Sci. 34:113-118. 1959.

Baumann, E.R., joint author. See under Willrich.
Baumann, R.V., joint author. See under Heady.
Beal, G.M., joint author. See under Rogers.

58. Bear, William Forrest. Relation of high school vocational agriculture to mechanical farm jobs performed by graduates. The Agric. Educ. Mag. 32:161-162. 1960.

59. Beecroft, R.I. and C.A. Swenson. The behavior of polytetrafluorethylene (Teflon) under high pressures. Jour. Appl. Phys. 30:1793-1798. 1959.

Beer, C.E., joint author. See under Gray, D.M.
Beerntsen, D.J., joint author. See under Peterson, D.T.

60. Beers, Russell J., William R. Lockhart, and Earle S. Raun. Some characteristics of bacteria isolated from diseased larvae of the European corn borer. Proc. Iowa Acad. Sci. 66:504-507. 1959.

_____, joint author. See under Raun.
Behrendt, D.R., joint author. See under Liu.
Beneke, R., joint author. See under Fuller, Krause, Wakeley.
Bennett, W.H., joint author. See under Woolley.
Beresford, H., joint author. See under Charity.

61. Berlyn, Graeme P. A biometric technique for reaction tissue research. Proc. Iowa Acad. Sci. 66:98-102. 1959.

62. Bethea, R.M. and T.D. Wheelock. Gas chromatography effect of flow rate on optimum sample size for minimum values of retention time and HETP. Instrument Soc. Amer. Proc. Second Biannual Gas Chromatography Symp. 2:1-4c. 1959.

63. _____ and _____. Gas chromatography of the C_1 to C_4 nitroparaffins. Anal. Chem. 31:1834-1836. 1959.

64. Beveridge, Elizabeth. Smooth floor or carpet? Iowa Farm Sci. 14:822-824. 1959.

65. _____. Training home economists for equipment positions. Jour. Home Econ. 52:365-366. 1960.

66. _____. The contribution of household equipment research. Jour. Home Econ. 51:858-860. 1959.

67. _____, Glenn R. Hawkes and Emil Hebe. Carpet and smooth floor covering --maintenance required and satisfactions to users. Jour. Home Econ. 51:780-785. 1959.

68. Beveridge, J.L., and C.P. Wilsie. Influence of depth of planting, seed size and variety on emergence and seedling vigor in alfalfa. Agron. Jour. 51:731-734. 1959.

Biester, A., joint author. See under Burrill.

69. Biester, H.E. and L.H. Schwarte. Editors, Diseases of Poultry. 4th ed. 1959. Iowa State University Press, Ames.

Bishop, C.A., joint author. See under DePuy.

70. Bisque, Ramon E. and John Lemish. Silicification of carbonate aggregates in concrete. Highway Res. Board Bull. 239. pp.41-55. 1960.

_____, joint author. See under Lemish.
Black, C. A., joint author. See under Dos Santos.
_____, Associate Editor. Soil Science Society of America Proceedings.
_____, Editor-in-Chief. Methods of Soil Analysis.
_____, Consulting Editor. Soil Science.
Bockhop, C.W., joint author. See under Barnes.
Bohlen, J.M., joint author. See under Wakeley.

71. Boles, Donald E. A look at county government. Iowa Farm Sci. 14(2):3-6. 1959.
72. _____. Chinese Confucianism and Communist power. World Affairs Quart. 30:226-240. 1959.
_____, joint author. See under Holmes.
73. Bolie, Victor W. Low level microwave power meter. United States Patent 2,901,700. August 25, 1959. Library of Congress.
74. _____. Decade to binary converter. U.S. Patent 2,905,935. U.S. Patent Office and Library of Congress. 1959.
75. Bonham, R.A. and L.S. Bartell. The molecular structure and rotational isomerization of n-butane. Jour. Amer. Chem. Soc. 81:3491-3496. 1959.
76. _____ and _____. Rapid procedure for rigorous analysis of electron diffraction data. The Jour. Chem. Physics 31:702-708. 1959.
77. _____, _____, and D.A. Kohl. The molecular structures of n-pentane, n-hexane and n-heptane. Jour. Amer. Chem. Soc. 81:4765-4769. 1959.
_____, joint author. See under Bartell.
Borduin, W.G., joint author. See under Hammond.
78. Bowen, C.C. Manual de tecniacas para preparaciones citologicas en plantas. Comunicaciones de Turrialba No. 67. Instituto Interamericano de Ciencias Agricolas. 20 pp. 1960.
Bowerman, A.M., joint author. See under Duncan.
Bowman, A.L., joint author. See under Duke.
79. Bowne, J.G. and F.K. Ramsey. Mixed mammary gland tumor studies in an aged dog. Iowa State University Veterinarian XXII(3):126-190. 1960.
Boylan, D.R., joint author. See under Wheelock.
Braestrup, F.W., joint author. See under Errington.
Bragonier, W.H., joint author. See under Engelhard, Thompson, H.E.
80. Bremner, J.M. Determination of fixed ammonium in soil. Jour. Agric. Sci. 52:147-160. 1959.
81. _____ and T. Harada. Release of ammonium and organic matter from soil by hydrofluoric acid. Jour. Agric. Sci. 52:137-146. 1959.
_____, joint author. See under McDonnell, Scott.
82. Brigham, Raymond D. Effect of cercospora disease on forage quality of alfalfa. Agron. Jour. 51:365. 1959.
Brockway, L.O., joint author. See under Bartell.
Brown, E.B., Jr., joint author. See under Thompson, A.M.
Brown, H.E., joint author. See under Grogan, Speer.
Brown, L.R., joint author. See under Hartman, Johnson, R.H.
Brown, N., joint author. See under Grogan.
83. Browning, J.A. and K.J. Frey. The inheritance of new sources of oat stem rust resistance. Plant Disease Reporter 43:768-771. 1959.
84. _____ and Don C. Peters. Yellow dwarf of oats in Iowa in 1959. Plant Dis. Reptr. Suppl. 262. 44:336-341. 1959.
85. _____, _____ and K.J. Frey. Virus + aphids + oats = yellow dwarf of oats. Iowa Farm Sci. 14:462-464. 1960.
86. _____, J.G. Wheat, and K.J. Frey. Yellow dwarf of oats in Iowa in 1959. Plant Dis. Reptr. Suppl. 262. 44:336-341. 1959.
_____, joint author. See under Frey.
87. Bryan, John H.D. and J.W. Gowen. X-ray effects on mitotic activity of the accessory sex organs of castrate rats stimulated by testosterone propionate. Biological Bull. 117:68-80. 1959.
_____, joint author. See under Hollander.

88. Bryant, Edward C., H.O. Hartley, and R.J. Jessen. Design and estimation in two-way stratification. Jour. Amer. Stat. Assoc. 55:105-124. 1960.

Bryant, R.L., joint author. See under Card.

89. Buchanan, R.E. Book Review: Staphylococcus pyogenes and its relation to disease, by Stephen D. Elek. Internatl. Bull. Bact. Nomen. and Taxon. 10(2):80-84. 1960.

90. _____. Book Review: A Guide to the Identification of the Genera of Bacteria, by V.B.D. Skerman. Internatl. Bull. Bact. Nomen. and Taxon. 10(2):79-80. 1960.

91. _____. Book Review: Atlas of Bacterial Flagellation, by Einar Leifson. Internatl. Bull. Bact. Nomen. and Taxon. 10(3):211-212. 1960.

92. _____. The international code of nomenclature of the bacteria and viruses. Syst. Zool. 8:27-39. 1959.

93. _____. Chemical terminology and microbiological nomenclature. Internatl. Bull. Bact. Nomen, and Taxon. 10(1):16-22. 1960.

94. _____. Committee on terminology in biological nomenclature of the International Union of Biological Sciences. Internatl. Bull. Bact. Nomen. and Taxon. 10(1):13-15. 1960.

_____, Editor-in-Chief. Iowa State Journal of Science.

_____, Editor. General Bacteriology Section, Biological Abstracts.

_____, Editor. International Bulletin of Bacteriological Nomenclature and Taxonomy.

95. Buck, Griffith J. Progress report on breeding hardy everblooming roses. Amer. Rose Ann. 45:95-99. 1960.

96. Buehler, Robert J. Some validity criteria for statistical inferences. Annals Math. Stat. 30:845-863. 1959.

_____, Abstractor. American Statistical Publications for the International Journal of Abstracts.

97. Buhl, Harold R. Understanding the creative engineer. Amer. Soc. Mech. Engr. Paper No. 60-SA-33. 1960.

98. _____. All you need is a handbook. Jour. Engr. Educ. 50:312-315. 1960.

99. _____. Creative Engineering Design. 1st ed. Iowa State University Press. 1960.

100. Bundy, Clarence E. and Ronald V. Diggins. Poultry Production. 1st ed. 370 pp. Prentice-Hall, Inc. 1960.

_____, joint author. See under Morgan.

101. Burchinal, Lee G. What's your son going to do? Iowa Farm Sci. 14:16-18. 1960.

102. _____. Rurality, item bias, and the application of scientific methodology to human behavior. Amer. Sociol. Rev. 25:257-260. 1960.

103. _____. School policies and school age marriages. Fam. Life Coord. 8:43-48. 1960.

104. _____. Who's going to farm? Iowa Farm Sci. 14:12-15. 1960.

105. _____. Comparisons of factors related to adjustment in pregnancy-provoked and nonpregnancy-provoked youthful marriages. Midwest Sociol. 21:92-96. 1959.

106. _____. Adolescent role deprivation and high school age marriage. Marriage and Family Living 21:378-384. 1959.

107. _____. Agreement of occupational prestige as ranked by two empirical occupational prestige scales. Jour. Soc. Psychol. 50:335-340. 1959.

108. _____. Do restrictive policies curb teen marriages? Overview 1:72-73. 1960.

109. _____. What about your daughter's future? Iowa Farm Sci. 14:9-10. 1960.

110. _____. Personality characteristics and sample bias. Jour. Appl. Psychol. 44:172-174. 1960.
_____, Abstract Editor. Marriage and Family Living.
111. Burrill, L.M., B. Alsup, C. Schuck, Harriet Roberts, Pearl Swanson, M.A. Ohlson, A. Biester, M. Hutchinson, M. Mangel, R. Leverton. Evaluation of the self-chosen weighed diets of 402 women 30-97 years of age in seven north central states. S. Dak. Agr. Exp. Sta. Bull. No.478. 19 pp. 1959. (Also NC Regional Publ. No.105.)
113. Burroughs, W., A. Raun, A. Trankle and Ned Raun. Further observations upon the effects of methimazole upon feedlot performance and carcass characteristics of fattening beef cattle. Jour. Anim. Sci. 19:465-469. 1960.
114. _____, W. Woods, S.A. Ewing, J. Greig, and B. Theurer. Enzyme additions to fattening cattle rations. Jour. Anim. Sci. 19:458-464. 1960.
_____, joint author. See under Cheng, Preston.
Burrows, W.C., joint author. See under Parker, Van Wijk.
Burwell, R.E., joint author. See under Larson, W.E.
115. Butcher, W. and E.O. Heady. One way to beat the surplus problem. Iowa Farm Sci. 14(10): 1960.
_____, joint author. See under Heady, Rigler.
Bystroff, R.I., joint author. See under Banks.

116. Cameron, William J. and William F. Kenkel. High school dating: A study in variation. Marriage and Family Living 22:74-76. 1960.
117. Card, L.E., W.J. Stadelman, F. Carlin, J.C. Ayres, J.L. Fry, L.E. Dawson, M.H. Swanson, O.J. Cotterill, R.E. Feeney, R.L. Bryant, A.R. Winter, C.W. Carlson, M.L. Sunde. Micro-organisms and their control on fresh poultry meat. North Central Reg. Publ. 112, Tech. Bull. 278. 40 pp. 1960.
Carlander, Kenneth D. Editorial Consultant. Copeia.
_____, Editorial Consultant. Limnology and Oceanography.
_____, Editorial Consultant. Tulane Studies in Zoology.
_____, Editorial Consultant. Transactions of the American Fisheries Society.
118. Carlin, Agnes Frances, Rose Marie Pangborn, V. Cotterill, and Paul G. Homeyer. Effect of pretreatment and type of packaging material on quality of frozen fried chicken. Food Technol. 8:557-560. 1959.
_____, joint author. See under Escanilla, Card, Wakeley.
119. Carlson, B.C. Fields of an accelerated point charge. Amer. Jour. Physics 27:669-670. 1959.
Carlson, C.W., joint author. See under Card.
120. Carlson, G.E. Counter-planter for grain sorghum in greenhouse flats. Agron. Jour. 52:367. 1960.
121. _____ and R.E. Atkins. Effect of freezing temperatures on seed viability and seedling vigor of grain sorghum. Agron. Jour. 52:329-333. 1960.
123. Carlson, O.N., D.T. Eash, and A.L. Eustice. Vanadium-tantalum and vanadium-chromium alloy systems. Proc. Third Annual Reactive Metals Conf., Metallurgical Soc. of the A.I.M.E. 2:277-295. 1959.

125. _____, J.A. Haefling, F.A. Schmidt, and F.H. Spedding. Preparation and refining of yttrium metal by Y-Mg alloy process. Jour. Electrochem. Soc. 107:540-545. 1960.
126. _____ and B.A. Loomis. Investigation of the brittle-ductile transition in vanadium. Chapter in: Reactive Metals, Vol. 2, pp. 227-243. Interscience Publishers, New York. 1959.
_____, joint author. See under Gibson, Eash, Deardorf.
127. Carr, Percy H., Robert M. Stewart, Jr., and Joseph H. Senne. Flash period of 1958 delta I. Amer. Jour. Physics 28:64-66. 1960.
128. Carter, Harold and Earl O. Heady. An input-output analysis of American agriculture emphasizing regional and commodity sectors. Iowa Agric. and Home Econ. Exp. Sta. Res. Bull. 469. 1959.
_____, joint author. See under Heady.
Catron, D.V., joint author. See under Acker, D.C., Frape, Hays, Johnson, C.W., Quinn, Speer, Wilbur, Zimmerman, D.R.
Cavert, H.M., joint author. See under Thompson, A.M.
129. Chadderdon, H. and Ella Joyce Croft. Prediction of clothing construction achievement of high school girls. Educ. and Psychol. Measurement 19:653-655. 1959.
Chang, C.C., joint author. See under Hsu.
130. Chapman, O.L. and D.J. Pasto. A novel base-catalyzed isomerization of a bicyclic system to a troponoid system. Jour. Amer. Chem. Soc. 81:5510. 1959.
131. _____ and _____. Photochemical transformations of single troponoid systems. I. Photo-γ-tropolone methyl ether. Jour. Amer. Chem. Soc. 82:3642-3648. 1960.
_____, joint author. See under Meinwald.
132. Charity, L.F., H. Beresford, and L.B. Altman. Electric house heating. Mutual Ins. Bull., Natl. Assoc. Mut. Ins. Co. 46(10). 1959.
_____, joint author. See under Holmes.
133. Charles, Don C. and Sally Pritchard. Differential development of intelligence in the college years. Jour. Genetic Psychol. 95:41-44. 1959.
134. Chang, Chieh-Chien and Cheng-Ting Hsu. Aerodynamic instability of supersonic inlet diffusers. Jour. Amer. Rocket Soc. 30:468-475. 1960.
135. Cheng, E. and W. Burroughs. Estrogenic substances in forages. pp. 195-202 in Grasslands, Amer. Assoc. Adv. Sci. 1959.
Childs, H.E., joint author. See under Schneider.
136. Chiotti, P. and G.R. Kilp. Vapor pressure and thermodynamic properties of Zn-Zr and Zn-U alloys. Trans. Mettalurg. Soc. of A.I.M.E. 218:41-44. 1960.
137. _____ and _____. Zinc-zirconium system. Trans. Mettalurg. Soc. of A.I.M.E. 216:892-898. 1959.
138. Choudhury, R. Basu Roy. Estimation of unsaturation of fats and oils, using hypochlorous acid. Jour. Amer. Oil Chem. Soc. 37:198-199. 1960.
_____, joint author. See under Arnold.
Christian, J.L., joint author. See under Smith, J.F.
139. Christie, B.R. and R.R. Kalton. Inheritance of seed weight and associated traits in bromegrass, Bromus inermis Leyss. Canadian Jour. Plant Sci. 40:353-365. 1960.
Chu, C.W., joint author. See under Hsu.
Clampitt, B.H., joint author. See under Hansen, R.S.

141. Clark, T.B. Comparative morphology of four genera of Trypanosomatidae. Jour. Protozool. 6(3):227-232. 1959.
142. _____ and F.G. Wallace. A comparative study of kinetoplast ultrastructure in the Trypanosomatidae. Jour. Protozool. 7(2):115-124. 1960.
Claus, G.W., joint author. See under Baugh.
143. Clikeman, F.M. and M.G. Stewart. The influence of 1-forbiddeness on 82-kev transition in Cs^{133}. Phys. Rev. 117:1052-1055. 1960.
Cockerham, C.C., joint author. See under Matzinger.
Cochran, D.G., joint author. See under Craig.
Coffin, W.J., joint author. See under Walker.
144. Cole, Wayne S. Senator Key Pittman and American neutrality policies, 1933-1940. Mississippi Valley Historical Rev. 46:644-662. 1960.
145. Collier, Joe E. Changes in fish populations and food habits of yellow bass in North Twin Lake, 1956-1958. Iowa Acad. Sci. Proc. 66:518-522. 1959.
146. Collins, E.V. Tandem tractor features. Trans. Amer. Soc. Agric. Engr. 2:13-15. 1959.
147. Collins, Peter, and Harvey Diehl. Determination of iron in urine using 4, 7-diphenyl-1, 10-phenanthroline. Anal. Chem. 31:1692-1693. 1959.
148. _____, _____, and G. Frederick Smith. 2, 4, 6-Tripyridyl-s-triazine as a reagent for iron. Determination of iron in limestone, silicates and refractories. Anal. Chem. 31:1862-1868. 1959.
149. Conover, D.F. and R.A. Ralston. Results of crop-tree thinning and pruning in northern hardwood saplings after nineteen years. Jour. Forestry 57:551-557. 1959.
Conrad, E.E., joint author. See under Kniseley.
Cook, H.C., joint author. See under Holmes.
Coolidge, J.H., joint author. See under Nichter.
Coon, B.I., joint author. See under Monroe.
150. Cooper, Glenn A. Specific gravity of red pine as related to stem and crown-formed wood. Iowa State Jour. Sci. 34:693-708. 1960.
Cope, J.T. Jr., joint author. See under Lathwell.
151. Corbett, John D. and Frank C. Albers. An electromotive force investigation of the product of the solution of antimony in liquid antimony triiodide. Jour. Amer. Chem. Soc. 82:533-535. 1960.
Corbett, J.D., joint author. See under Druding.
152. Cott, A.E., H. Gunderson, and M.C. Shurtleff. Home orchard spray schedule. Agric. and Home Econ. Ext. Res. Paper No.175. 4 pp. 1960.
Cotterill, O.J., joint author. See under Card.
Cotterill, V., joint author. See under Carlin.
153. Craig, George B. Jr., Donald G. Cochran and Walter C. Rothenbuhler. Genetics and the E.S.A. Bull. Ent. Soc. Amer. 6:100. 1960.
Croft, Ella Joyce, joint author. See under Chadderdon.
155. Curry, M.A., S. Legvold, and F.H. Spedding. Electrical resistivity of europium and ytterbium. Phys. Rev. 117:953-954. 1960.

Daane, A.H., joint author. See under Spedding.
156. Dahm, P.A., J. Gurland, E.T. Hibbs, W.H. Orgell, W.O. Pfaeffle, and I. Lee. Field sampling of alfalfa for the estimation of guthion residues. Jour. Econ. Ent. 52:791-798. 1959.
_____, joint author. See under Johnsen, R.E.
_____, Editorial Committee, Annual Review of Entomology, Annual Reviews, Inc., Palo Alto, California.

157. Daniel, H. Theory of a high-resolution beta-ray spectrometer with high luminosity. Rev. Scient. Instr. 31:249-252. 1960.
158. _____ and G.W. Eakins. Beta-gamma directional correlation in the decay of Co^{60} and Na^{22}. Physical Rev. 117:1565-1567. 1960.
159. _____, G. Schupp, and E.N. Jensen. Continuous electron spectrum accompanying K-capture. Physical Rev. 117:823-827. 1960.
160. Daniels, R.B. Entrenchment of the willow drainage ditch, Harrison County, Iowa. Amer. Jour. Sci. 258:161-176. 1960.

Danielson, G.C., joint author. See under Wallace.

161. Davison, K.L. and W. Woods. Influence of fatty acids upon digestibility of ration components by lambs and upon cellulose digestion in vitro. Jour. Anim. Sci. 19:54-59. 1960.

Dawson, L.E., joint author. See under Card.

162. Day, B.N., L.L. Anderson, L.N. Hazel, and R.M. Melampy. Synchronization of estrus and ovulation in swine. Jour. Anim. Sci. 18:909-917. 1959.
163. Dean, G.W. and Earl O. Heady. Changes in supply functions and supply elasticities in hog production. Iowa Agric. and Home Econ. Exp. Sta. Res. Bull. 471. 1959.
164. Deardorff, D.K., O.N. Carlson, and H. Kato. Hafnium alloy systems. Chapter in: The Metallurgy of Hafnium. 1st ed. U.S. Atomic Energy Comm., U.S. Govt. Printing Office, Washington, D.C. 1960.

Decoteau, A.E., joint author. See under Eshelman.

Deitschman, G.H., joint author. See under Thomson, G.W.

De Long, R.A., joint author. See under Kalton.

Denenberg, V.H., joint author. See under Karas.

165. Denisen, Ervin L. Cyclone, a new strawberry for your garden. Iowa Farm Sci. 14(6):5-6. 1959.
166. Denmead, O.T. and R.H. Shaw. Evapotranspiration in relation to the development of the corn crop. Agron. Jour. 51:725-726. 1959.
167. _____ and _____. The effects of soil moisture stress at different stages of growth on the development and yield of corn. Agron. Jour. 52:272-274. 1960.
168. DePuy, C.H. and C.A. Bishop. Electronic effects in elimination reactions. IV. Elimination of beta-phenylethyl derivatives in t-butyl alcohol. Jour. Amer. Chem. Soc. 82:2532-2535. 1960.
169. _____ and _____. Electronic effects in elimination reactions. V. The E_2 reaction of beta-phenylethyl fluorides and chlorides. Jour. Amer. Chem. Soc. 82:2535-2537. 1960.
170. _____ and K.D. Eilers. A simple large scale synthesis of cyclopentenone. Jour. Organic Chem. 24:1380. 1959.
171. _____ and D.H. Froemsdorf. Electronic effects in elimination reactions. III. Sulfonylhydrazone eliminations. Jour. Amer. Chem. Soc. 82: 634-636. 1960.
172. _____, R.W. King and D.H. Froemsdorf. Pyrolytic elimination of acetates: Isotope effect, relative reactivity and mechanism. Tetrahedron 7:123-129. 1959.
173. _____ and C.E. Lyons. Cyclopentene-3,5-dione. II. Conversion to cyclopentadienone. Jour. Amer. Chem. Soc. 82:631-633. 1960.
174. _____, I.A. Ogawa, and J.C. McDaniels. The solvolysis of exo and endo-7-isopropylidene-dehydronorbornyl tosylates. Jour. Amer. Chem. Soc. 82:2397-2398. 1960.
175. _____ and B.W. Ponder. Levulinic acid as a reagent for the hydrolysis of oximes and 2,4-dinitrophenylhydrazones. Jour. Amer. Chem. Soc. 81:4629-4631. 1959.

176. _____ and P.R. Story. The synthesis of 2,7-disubstituted norbornanes. Jour. Amer. Chem. Soc. 82:627-631. 1960.
177. _____ and _____. A convenient atmospheric pressure hydrogenation apparatus. Jour. Chem. Educ. 37:48. 1959.
178. _____ and _____. Gas chromatographic evidence for intramolecular hydrogen bonding with double bonds. Tetrahedron Letters 6:20-21. 1959.
179. _____ and E.F. Zaweski. Cyclopentene-3,5-dione. I. Synthesis and properties. Jour. Amer. Chem. Soc. 81:4920-4924. 1959.

Dicke, F.F., joint author. See under Penny.

180. Diehl, Harvey and G. Frederick Smith. The improved preparation of sulphatoceric acid for preparation of standard titrimetric solutions. Talanta 2:382. 1959.
181. _____ and _____. The iron reagents: bathophenanthroline, 2,4,6-tripyridyl-s-triazine, phenyl-2-pyrodyl ketoxime. 1st ed. 50 pp. G. Frederick Smith Chemical Company, Columbus, Ohio.
182. _____ and _____. Wet oxidation of organic matter employing mixed perchloric and sulphuric acids at controlled temperatures and graded high potentials. Talanta 2:209-219. 1959.

_____, joint author. See under Collins, Kratochvil, Smith, C.F., Trusell.

_____, Editorial Board. Talanta.

183. Diehl, J.W. and H. Gilman. Reduction of ketones by diphenylsilane. Chemistry and Industry 1095-1096. 1959.

_____, joint author. See under Gilman.

Diggins, R.V., joint author. See under Bundy.

184. Dillon, John L. and R.G. Mauldon. Inventory analysis and the economics of fodder conservation. The Economic Record 35:209,218. 1959.

_____, joint author. See under Mauldon.

Dixon, J.M., joint author. See under Richardson.

Doll, J.P., joint author. See under Heady, Pesek.

185. Dos Santos, A.F., M.T. Eid, A. Van Diest, and C.A. Black. Evaluation of biological indexes of soil phosphorus availability. Soil Sci. 89:137-144. 1960.
186. Drabick, Lawrence William. The teacher's day: analysis of professional role perceptions. Educ. Admin. and Supervision 45:329-336. 1959.
187. Druding, Leonard F. and John D. Corbett. Rare earth metal-metal halide systems. The preparation of neodymium(II) halides. Jour. Amer. Chem. Soc. 81:5512. 1959.
188. Drury, Horace F. and Stanley Galen Smith. Emergency food value of Alaskan wild plants. Alaskan Air Command, Arctic Aeromedical Lab. Tech. Note AAL-TN-57-16. 1st ed. 47 pp. 1957.
189. Duerr, William A. and Frederick S. Hopkins, Jr. Teaching forestry economics. Iowa State Jour. Sci. 34:507-512. 1960.
190. Duke, F.R. Mechanisms of oxidation-reduction reactions. Interscience Encyclopedia, Inc., New York, 31 pp. 1959.
191. _____. Oxidation-reduction equilibria and titration curves. Interscience Encyclopedia, Inc., New York. 1st ed. 1959.
192. _____ and Allen L. Bowman. Transport numbers in pure fused salts. The alkali metal chlorides. Jour. Electrochem. Soc. 106:626-627. 1959.
193. _____, _____, E. Wolf and H. Garfinkel. Ion mobilities in pure fused silver chloride. Annals New York Acad. Sci. 79:1023-1025. 1960.
194. _____ and W.W. Lawrence. Complex formation constants of lead and cadmium ions with chloride in fused lithium perchlorate. Jour. Phys. Chem. 63:2087-2088. 1959.

195. _____ and N.C. Peterson. The Sn(II) reduction of methyl orange. Jour. Phys. Chem. 63:2076-2077. 1959.
196. _____ and E. Wolf. The effect of some organic compounds on the rate of the Fe(II)-Fe(III) exchange. Iowa State Jour. Sci. 34:157-162. 1959.
197. _____ and S. Yamamoto. Acid-base reactions in fused salts. II. The absolute concentration of NO_2^+ ion in fused nitrate. Jour. Amer. Chem. Soc. 81:6378-6379. 1959.
198. Duncan, E.R., Wallace Ogg, Louise Rosenfeld, John T. Pesek, Jr., Margaret Liston, Virgil Hurlburt, Garold Parks, Geoffrey Shepherd, and Alvin Egbert. Action for agriculture by public agencies. Center for Agric. and Econ. Adjust. Rept. 4. 314 pp. 1959.
199. _____ and F.W. Schaller. Fitting conservation into the picture. Extension Serv. Rev. 30(8):8-9. 1959.
_____, joint author. See under Shaw, Thompson, H.E.
_____, Editor. Soils and Crops Section 5, Midwest Farm Handbook.
200. Duncan, G.W., A.M. Bowerman, W.R. Hearn, and R.M. Melampy. In vitro synthesis of progesterone by swine corpora lutea. Proc. Soc. Exper. Biol. and Med. 104:17-19. 1960.
201. Dunham, Jewett and Robert E. Haupt. Laboratory Manual for General Zoology. 1st ed. 190 pp. Burgess Publishing Co. 1960.
202. Dunleavy, John. X-ray irradiation of soybean seed as a technique for production of disease-resistant plants. Proc. Iowa Acad. Sci. 66:113-122. 1959.
_____, joint author. See under Grabe.
203. Dunning, Wayne W. and Don S. Martin, Jr. Mixed tetra-(chlorobromo)-platinates(II). Equilibrium constants for formation in aqueous solution. Jour. Amer. Chem. Soc. 81:5566-5570. 1959.
Durand, D., joint author. See under Greenwood.

Eakins, G.W., joint author. See under Daniel.
204. Earls, Lester T. Book Review: Concepts of Classical Optics, by John Strong. Spectrochimica Acta 15:899-900. 1959.
205. Eash, D.T. and O.N. Carlson. Investigation of the thorium-yttrium system. Trans. Amer. Soc. for Metals 52:1097-1114. 1960.
_____, joint author. See under Carlson, O.N.
206. Ecker, R.E. and W.R. Lockhart. Influence of initial population on the length of lag. Bacteriol. Proc. 60:165. 1960.
Edwards, A.P., joint author. See under Scott.
Egbert, A.C., joint author. See under Duncan, E.R., Heady.
207. Eggenberger, Lewis. Farm machinery workshop helps teachers keep up-to-date. The Agric. Educ. Mag. 32:146-168. 1960.
Eid, M.T., joint author. See under Dos Santos.
Eilers, K.D., joint author. See under De Puy.
Eisch, J., joint author. See under Gilman.
Ekberg, C.E. Jr., joint author. See under Assinacopoulos.
208. Eldredge, J.C..and W.I. Thomas. Popcorn in the home. Iowa Agric. and Home Econ. Ext. Res. Paper No.260. 4 pp. 1959.
209. Eldridge, Eber. A new focus for extension. Farm Policy Forum. 11(4):15-20. 1959.
210. Elford, C.R. and R.H. Shaw. The climate of Iowa. Soil temperatures at Ames. Spec. Rept. No.24. Iowa State University, Ames. 1960.
Ellerhoff, M.A., joint author. See under Hendrickson.
211. Engelhard, A.W. and W.H. Bragonier. Squirrels as possible vectors of the oak wilt fungus in Iowa. Plant Dis. Rptr. 44:192-196. 1960.

212. Eppright, Ercel S. The challenge of today - challenge to the profession. Jour. Home Econ. 50:690-693. 1959.
213. _____. Food habits of the teen-ager. The Nation's Schools 64:64-68. 1959.
214. _____, Charlotte E. Roderuck, and Virginia D. Sidwell. Nutrition of 9-, 10- and 11-year old public school children in Iowa, Kansas,and Ohio. III. Physical findings. North Central Reg. Bull. No.99. 24 pp. 1959. (Also Kansas Agr. Home Ec. Exper. Sta. Tech. Bull. No.101.)
_____, joint author. See under Monroe.
_____, Board of Editors. Practical Home Economics.
Ericson, L., joint author. See under Shrader.
216. Erlander, S.R. The production of amylose and amylopectin in corn endosperms and in potato tubers. Cereal Chem. 37:81-93. 1960.
217. Errington, P.L. Wetland saga. Natural History 69:8-15. 1960.
218. _____. Of marshes and spring (chapter selection from Of Men and Marshes). In Approaches to Prose, by Caroline Shrodes and Justine Van gundy. Macmillan. 1959.
219. _____ and F.W. Braestrup. Rovdyrene og deres virkninger—nogle synspunkter. (in Danish) (Predatory animals and their effects—some viewpoints.) Naturens Verden pp.71-81. 1960.
220. Escanilla, Ofelia I., Agnes Frances Carlin and John C. Ayres. Effect of storage and of cooking on chlortetracycline residues in meat. Food Technol. 13:520-524. 1959.
221. Eshelman, L.R., E.Y. Manzo, S. Marcus, A.E. Decoteau, and E.G. Hammond. The determination of trisaturated glycerides in fats with mercaptoacetic acid. Anal. Chem. 32:844. 1960.
Eustice, A.L., joint author. See under Carlson, O.N.
Evans, R.L., joint author. See under Thompson, A.M.
Evens, F.M., joint author. See under Fassel.
222. Everson, L.E. The future of seed technology. (Presidential address) Proc. Assoc. Off. Seed Analysts 49(1):32-34. 1959.
Ewing, S.A., joint author. See under Burroughs.
223. Ezekiel, Mordecai and Karl A. Fox. Methods of Correlation and Regression Analysis: Linear and Curvilinear. 3rd ed. 548 pp. John Wiley and Sons, New York. 1959.

224. Fabiny, Robert John. Fixative and post-mortem changes in the morphology of duodenal villi. Anatomical Record 135:225-235. 1959.
225. _____. Effects of versene and β-2 thienylalanine on the developing down feather. Amer. Jour. Anatomy 104:275-293. 1959.
Fairchild, M.L., joint author. See under Johnsen, R.E.
226. Fassel, Velmer A. Emission spectrometric determination of oxygen, nitrogen and hydrogen in metals. Jour. Iron and Steel Inst. 16:443-449. 1959.
227. _____ and Lawrence L. Altpeter. Emission spectrometric determination of the gaseous elements in metals VI. Oxygen in vanadium. Spectrochimica Acta 16:443-449. 1959.
228. _____, W.A. Gordon, and R.J. Jasinski. Spectrographic determination of oxygen, nitrogen, and hydrogen in metals. In: Progress in Nuclear Energy-Analytical Chemistry. 1:230-243. Pergamon Press. 1959.
229. _____, William A. Gordon, Raymond J. Jasinski, and F. Monte Evens. Emission spectrometric determination of the gaseous elements in metals. Revue Universelle des Mines 15:278-281. 1959.
_____, joint author. See under Gray, Horrigan, Kniseley.
_____, Editor. Spectrochimica Acta.

230. Fedkiw, John, Frederick S. Hopkins, Jr., and Neil Stout. Economic aspects of growing high quality pine through pruning. Northeastern Logger 8(10):16-21. 1960.
Feeney, R.E., joint author. See under Card.
Fielder, L., joint author. See under Fuller.
231. Fitzwater, D.R. and R.E. Rundle. Crystal structure of hydrated erbium, yttrium and praseodymium ethylsulfates. Zeitschrift für Kristallographie 112:362-374. 1959.
Fletcher, W.E., joint author. See under Mahlstede.
232. Foley, D.C. The response of corn to inoculation with Diplodia zeae and Gibberella zeae. Phytopathology 50:146-150. 1960.
233. Fox, Karl A. The current state of agricultural economics: Methods and potentials in agricultural economics research. Jour. Farm Econ. 41(5):909-915. 1959.
234. _____. The small world—our century's challenge to democracy. Farm Policy Forum 12(2):2-6. 1959-60.
235. _____. Book Review: Economic Forecasts and Policy, by H. Theil. The Amer. Econ. Rev. 49(4):711-716. 1959.
236. _____. Book Review: Allocation in Space; Production, Transport and Industrial Location, by Louis Lefeber. Econometrica 27(4):718-720. 1959.
237. _____. Do we have depressions licked? Iowa Farm Sci. 14(1):287-289. 1959.
239. _____. Economic instability and agricultural adjustment. Chapter 8, pp.114-158, in Problems and Policies of American Agriculture. Iowa State University Press. 1st ed, 460 pp. 1959.
_____, joint author. See under Ezekiel.
240. Frape, D.L., V.C. Speer, V.W. Hays, and D.V. Catron. Thyroid function in the young pig and its relationship with vitamin A. Jour. Nutrition 68:333-341. 1959.
Frederick, L.R., joint author. See under Sabey.
Free, G.R., joint author. See under Lovely.
Freeman, A.E., joint author. See under Johnsen, R.E.
241. Fremling, C.R. Subimaginal molt of Caenis hilaris (Say) (Ephemeroptera: Caenidae). Entomol. News 71:14. 1960.
242. French, Dexter. Book Review: Advances in Carbohydrate Chemistry, Vol. 13. Jour. Chem. Educ. 36:A710-A712. 1959.
243. _____, R. William Youngquist, and Alice Lee. Isolation and crystallization of planteose from mint seeds. Arch. Biochem. and Biophys. 85:471-473. 1959.
_____, joint author. See under Thoma.
244. Frey, K.J. The relation between environmental and genetic variances for heading data and plant heights in oats. Agron. Jour. 51:545-546. 1959.
245. _____. Yield components in oats. I. Effect of seeding date. Agron. Jour. 51:381-383. 1959.
246. _____. Yield components in oats. II. The effect of nitrogen fertilization. Agron. Jour. 51:605-608. 1959.
247. _____. Yield components in oats. III. Their contribution to the variety and location interaction for grain yield. Agron. Jour. 51:744-746. 1959.
248. _____. Yield components in oats. IV. Effect of delayed application of nitrogen. Proc. Iowa Acad. Sci. 66:137-142. 1959.
249. _____ and J.A. Browning. Yield losses from atypical oat blast in central Iowa in 1957. Proc. Iowa Acad. Sci. 66:129-136. 1959.

250. _____, H.C. Murphy, F. Petr, and A.J. Norden. Lodging resistance studies in oats. III. Optimum number of plots and samples for cL_r and snap scores. Agron. Jour. 52:289-291. 1960.
251. _____ and A.J. Norden. Lodging resistance studies in oats. II. Inheritance and heritability. Agron. Jour. 51:535-537. 1959.
_____, joint author. See under Browning, Gonzalez, Norden.
Frisbie, R., joint author. See under Monroe.
252. Fritschen, Leo J. Construction and calibration details of the thermal-transducer type net radiometer. Bull. Amer. Meteorol. Soc. 41:180-183. 1960.
253. Fritz, J.S. Educational trends? What they are and what they should be. Jour. Chem. Educ. 37:279-281. 1960.
254. _____ and Shirley K. Karraker. Ion exchange separation of metal cations. Anal. Chem. 32:957-960. 1960.
255. _____ and D.J. Pietrzyk. Photometric titration of scandium. Anal. Chem. 31:1157-1159. 1959.
256. _____ and G.H. Schenk. Acid-catalyzed acetylation of organic hydroxyl groups. Anal. Chem. 31:1808-1812. 1959.
Froemsdorf, D.H., joint author. See under De Puy.
Fry, J.L., joint author. See under Card.
257. Fuller, Wayne, Glen Purnell, Lonnie Fielder, Marvin Laursen, Ray Beneke, and Geoffrey Shepdherd. An alternative parity formula for agriculture. Iowa Agric. and Home Econ. Exp. Sta. Res. Bull. 476. pp. 689-722. 1960.
258. Futrell, Gene A. Your food bill—Too high? Iowa Farm Sci. 14(5):371-372. 1959.
259. _____ and Arnold Paulsen. Who'll gain more from livestock. Iowa Farm Sci. 14(6):391-392. 1959.
_____, joint author. See under Shepherd.

260. Gaarder, Raymond O., Norman V. Strand and Wilbur R. Maki. Consumer preferences for pork, Des Moines, Iowa. Iowa Agric. and Home Econ. Exp. Sta. Res. Bull. 477, pp. 725-744. 1960.
261. Gadsby, Dwight Maxon. Are Iowa land values tapering off? Iowa Farm Sci. 14(8):3-4. 1960.
262. Gage, R.S. and S. Aronoff. Translocation III. Experiments with carbon 14, chlorine 36, and hydrogen 3. Plant Physiology 35:53-64. 1960.
263. _____ and _____. Radioautography of tritiated photosynthate arising from HTO. Plant Physiology 35:65-68. 1960.
_____, joint author. See under Loomis.
264. Gaj, B.J. and H. Gilman. Clevage of hexaphenyldisilane by phenyllithium. Chem. and Industry, pp. 493-494. 1960.
265. _____ and _____. Reductive triphenylsilylation of N,N-disubstituted amides. Chem. and Industry, pp. 319-320. 1960.
266. Gardner, Bruce D. If your child doesn't listen. Today's Health 38:14, 85, 87-88. 1960.
267. _____. How's your personality? The Young Farmer. pp. 8-12. Fall, 1959.
Gardner, F.P., joint author. See under Wiggans.
Garfinkel, H., joint author. See under Duke.
Gartner, J., joint author. See under Kolmer.
268. Gates, C.E., C.R. Weber, and T.W. Horner. A linkage study of quantitative characters in a soybean cross. Agron. Jour. 52:45-49. 1960.

269. Gatherum, Gordon E. An analytical approach to the management of forest land for beef cattle and timber production. Iowa State Jour. Sci. 34:565-574. 1960.

Geisser, G., joint author. See under Richter.

270. George, B.W., E.S. Raun, D.C. Peters and C. Mendoza. Artificial medium for rearing some lepidopterous corn insects. Jour. Econ. Entomology 53(2):318-319. 1960.

271. George, M.V. and H. Gilman. Oxygen oxidation of triphenylsilyllithium. Jour. Amer. Chem. Soc. 81:3288, 3291. 1959.

272. _____, D.J. Peterson, and H. Gilman. Preparation of silyl- and germyl-metallic compounds. Jour. Amer. Chem. Soc. 82:403, 406. 1960.

_____, joint author. See under Wittenberg.

273. Gibbons, J.M. and E.O. Heady. More about choosing a hog system. Iowa Farm Sci. 14(8). 1960.

_____, joint author. See under Heady.

274. Gibson, E.D. and O.N. Carlson. The yttrium-magnesium alloy system. Trans. Metallurgical Soc. of A.I.M.E. 52:1084-1096. 1960.

275. Giese, Henry. Windstorm loss prevention. Proc. Natl. Assoc. Mut. Ins. Companies, pp.117-126. 1959.

276. Gilkey, H.J. Definition of engineering—a counter proposal. Jour. Engr. Educ. 50(3):257-261. 1959.

277. _____ and W.C. White. Definition of Engineering. Jour. Engr. Educ. 50(10):892-895. 1960.

Gillespie, J.P., joint author. See under Pohl.

278. Gilman, H. Organometallic Compounds. Metal Organic Compounds, Advances in Chemistry Series 23:1-9. Published by American Chemical Society, 1st ed. 1959.

279. _____ and J.W. Diehl. Orientation in the 10-thiaxanthenone nucleus. Jour. Organic Chem. 24:1914-1916. 1959.

280. _____, J. Eisch and T.S. Soddy. The preparation and rearrangement of 2-allyl-1,2-dihydroquinoline. Jour. Amer. Chem. Soc. 81:4000-4003. 1959.

281. _____ and G.D. Lichtenwalter. A new synthesis of organothiosilanes. Jour. Organic Chem. 25:1064-1065. 1960.

282. _____ and _____. Scission of the silicon-silicon bond in halogenated polysilanes of organometallic reagents. Jour. Organic Chem. 24: 1588-1590. 1959.

283. _____, _____, and D. Wittenberg. Cleavage studies of disilanes by silyllithium compounds. Jour. Amer. Chem. Soc. 81:5320-5322. 1959.

284. _____, D.J. Peterson, A.W. Jarvie, and H.J.S. Winkler. The reaction of dichlorodiphenylsilane with sodium. Jour. Amer. Chem. Soc. 82:2076. 1960.

285. _____ and S.D. Rosenberg. Benzyllithium from triphenylbenzyltin and phenyllithium. Jour. Organic Chem. 24:2063-2064. 1959.

286. _____ and W. Steudel. Diphenylsilylithium, a new type of organometallic compound. Chemistry and Industry, p.1094. 1959.

287. _____ and E.A. Zuech. Selective reactions of the silicon-hydrogen group with Grignard reagents. The preparation of some unsymmetrical silane derivatives. Jour. Amer. Chem. Soc. 81:5925-5928. 1959.

288. _____ and _____. Phenazasiline compounds derived from di-p-tolylamine. Jour. Organic Chem. 24:1394-1395. 1959.

289. _____ and _____. Group IV-B element analogs of 5,10-dihydroacridine. Jour. Amer. Chem. Soc. 82:2522-2524. 1960.

290. _____ and _____. A novel cyclic organosilicon compound. Chemistry and Industry, p.120. 1960.
_____, joint author. See under Diehl, J.W., Gaj, George, Wittenberg, Wu.
_____, Editorial Board. Organic Syntheses.
Gjevre, J.A., joint author. See under Smith, J.F.
291. Goebel, Carl J. Effect of range condition and plant vigor upon the production and nutritive value of forage. Utah State University Bull. 51 pp. 1960.
292. Goetz, Charles A. and Robert C. Smith. Evaluation of various methods and reagents for total hardness and calcium hardness in water. Iowa State Jour. Sci. 34:81-112. 1959.
Goetzinger, J.W., joint author. See under Horrigan.
293. Gohman, Richard W. Cooling effect detectors for forced cooled electronic equipment. Collins Engineering Report, Collins Radio Co., Cedar Rapids, Iowa. 37 pp. 1960.
294. Gonzales, C.L. and K.J. Frey. Effect of seed size and hulls upon X-ray sensitivity of oat seeds. Proc. Iowa Acad. Sci. 66:123-128. 1959.
295. Good, R.H., Jr., and M.E. Rose. Transverse polarization in allowed beta transitions. Il Nuovo Cimento 14:872-886. 1959.
_____, joint author. See under Hammer, Liu, Rose.
Gordon, W.A., joint author. See under Fassel.
296. Goto, Etsuo and A.W. Nordskog. Heterosis in poultry. 4. Estimation of combining ability variance from diallel crosses of inbred lines in the fowl. Poultry Sci. 38:1381-1388. 1959.
297. Gowen, J.W. Genetic effects in nonspecific resistance to infectious disease. Bact. Rev. 24:192-200. 1960.
298. _____. A Drosophila intersex-triploid. Genetics 45:139-142. 1960.
_____, joint author. See under Bryan, Hollander.
299. Grabe, Don F. and John Dunleavy. Physiologic specialization in Peronospora manshurica. Phytopathology 49:791-793. 1959.
_____, Chairman, Subcommittee for Indexing Proceedings. Assoc. of Official Seed Analysts.
300. Graham, Jewel. Teas, parties, buffets. Iowa Agric. and Home Econ. Ext. Res. Paper No.HE-6. 24 pp. 1959.
301. _____. Look to your skillet skills. Iowa Agric. and Home Econ. Ext. Res. Paper No.HE-43. 4 pp. 1960.
302. Gray, D.M. and C.E. Beer. Factors affecting selection of proper "length-of-run" as applied to furrow irrigation design. Canadian Soc. Agric. Engr. 2:20-23, 40. 1960.
_____, joint author. See under Shrader.
303. Gray, L.S. Jr., V.A. Fassel, and R.N. Kniseley. Use of nitrogen-15 for the characterization of infrared bands arising from nitrogen vibrations. Spectrochimica Acta 16:514-517. 1960.
304. Greene, John C. The Death of Adam: Evaluation and its Impact on Western Thought. 1st ed. 388 pp. Iowa State University Press. 1959.
305. _____. Darwin and religion. Proc. Amer. Philos. Soc. 103:716-725. 1959.
306. _____. Biology and social theory in the nineteenth century: Auguste Comte and Herbert Spencer. pp.419-446 in: Critical Problems in the History of Science. University of Wisconsin Press. 1959.
307. Greenwood, J. Arthur and David Durand. Aids for fitting the gamma distribution by maximum likelihood. Technometrics 2:55-65. 1960.
Greig, J., joint author. See under Burroughs.
Greiner, J.D., joint author. See under Smith, J.F.

308. Grogan, C.O., M.S. Zuber, Norman Brown, D.C. Peters, and H.E. Brown. Date-of-planting studies with corn. Univ. of Missouri Agric. Exp. Sta. Res. Bull. 706. 68 pp. 1959.
309. Gschneidner, Melba Pickenpaugh and Charlotte E. Roderuck. Nutriture of school girls of different physiques.. Jour. Amer. Dietetic Assoc. 36:22-26. 1960.

Guldner, J.S., joint author. See under Peckham.

310. Gunderson, Harold. Free your community of mosquitoes. Iowa Agric. and Home Econ. Ext. Res. Paper No.257. 6 pp. 1959.
311. _____. Burrowing animals in the lawn. Flower and Garden 4:30-31. 1960.
312. _____. Rodent and insect control. School Lunch Jour. 8:37-39. 1959.
313. _____ and E.S. Raun. Insect and rodent prospects for 1960. Iowa Farm Sci. 14:17-19. 1960.

_____, joint author. See under Cott, Roberts.

314. Gurland, John. Corrections to "Distribution of the maximum of the arithmetic mean of correlated random variables." Annals of Math. Stat. 30:1265-1266. 1959.
315. _____. Some applications of the negative binomial and other contagious distributions. Amer. Jour. Publ. Health and the Nation's Health. 49:1388-1399. 1959.

_____, joint author. See under Dahm.

316. Guter, Gerald A. and George S. Hammond. Chelates of β-diketones, III. Steric effects in the formation constants of metal chelates. Jour. Amer. Chem. Soc. 81:4686-4689. 1959.

_____, joint author. See under Hammond.

317. Gutierrez, Mario G. and G.F. Sprague. Randomness of mating in isolated polycross plantings of maize. Genetics 44:1075-1082. 1959.
318. Gwynne, Charles S. The works of running water. Iowa Conservationist 19(6):43. 1960.
319. _____. Building a park. Iowa Conservationist 19(4):27. 1960.
320. _____. Pikes Point. Iowa Conservationist. 19(1):5. 1960.

Haefling, J.A., joint author. See under Carlson, O.N.

321. Hall, P.M., S. Legvold, and F.H. Spedding. Electrical resistivity of dysprosium single crystals. Physical Rev. 117:971-973. 1960.

Hamilton, E.W., joint author. See under Orgell.

322. Hamilton, Howard L. Careers in Animal Biology. 2nd ed. rev. Iowa State University Press, Ames, Iowa. 1959.
323. Hammer, C.L. and R.H. Good, Jr. Four-fermion interactions with spin 3/2 neutrinos. Physical Rev. 117:889-890. 1960.
324. _____ and L. Jackson Laslett. Resonant beam extraction from an alternate gradient synchrotron. Bull. Amer. Phys. Soc. Ser.II. 5(4):225. 1960.

Hammond, E.H., joint author. See under Eshelman, Magnusson.

325. Hammond, George S., Wilfred G. Borduin and Gerald A. Guter. Chelates of β-diketones. I. Enolization and spectra. Jour. Amer. Chem. Soc. 81:4682-4686. 1959.

_____, joint author. See under Guter.

326. Hannum, Thomas E. The effects of smoking habits on the believability of lung cancer articles. Printer's Ink 268:55. 1959.
327. _____. The believability of some cigarette advertisements. Printer's Ink 268:52. 1959.

328. Hannum, Thomas E. Public relations. Part I. Custodian Training 23:28-30. Jan. 1960.
329. _____. Public relations. Part II. Cust. Train. 23:28-30. Feb. 1960.
Hansen, J.H., joint author. See under Wenkert.
330. Hansen, N.J. and I.I. Holland. A consumer preference study of charcoal in central Iowa. Iowa State Jour. Sci. 34:709-712. 1960.
Hansen, Ralph, joint author. See under Hull.
331. Hansen, Robert S. The theory of diffusion controlled adsorption kinetics with accompanying evaporation. Jour. Phys. Chem. 64:637-641. 1960.
332. _____, Robert E. Minturn and Bert H. Clampitt. Some studies of aqueous uranium oxide slurries. Nuclear Sci. and Engr. 6:458-460. 1959.
Hanway, J.J., joint author. See under Scott.
Harada, T., joint author. See under Bremner.
Harding, Delma E., joint author. See under Tauber.
334. Harl, N.E., J.F. Timmons, and J.C. O'Byrne. Incorporate the family farm? Iowa Farm Sci. 14(1). 1959.
_____, joint author. See under O'Byrne.
335. Harp, John. A general theory of social participation. Rural Sociology 24:7. 1959.
Harris, M., joint author. See under Roan.
336. Hart, R.H. and C.P. Wilsie. Inheritance of a flower character, brown keel tip, in Lotus corniculatus L. Agron. Jour. 51:379-380. 1959.
337. Hartley, H.O. Changes in the outlook of statistics brought about by modern computers. Proc. Third Conf. on Design of Experiments in Army Res. Devel. and Test. Office of Ordn. Res. U.S. Army, Durham, N.C. 1958.
338. _____. The efficiency of internal regression for the fitting of the exponential regression. Biometrika 46:293-295. 1959.
339. _____. Smallest composite designs for quadratic response surfaces. Biometrics 15:611-624. 1959.
340. _____. Analysis of variance. Chapter 20 in: Mathematical Methods for Digital Computers. John Wiley and Sons, Inc., New York and London. pp. 221-230. 1960.
_____, joint author. See under Bryant.
341. Hartman, Paul A. Enterococcus:coliform ratios in frozen chicken pies. Appl. Microbiol. 8:45-48. 1960.
342. _____. Further studies on the selectivity of violet red bile agar. Jour. Milk and Food Technol. 23:45-48. 1960.
343. _____, R.H. Johnson, L.R. Brown, N.L. Jacobson, and R.S. Allen. 1960 effect of diet and feed additive on facultative anaerobes in the rumen. Rept. 5th Conf. on Rumen Function, 1960. 1960:20-21. 1960.
_____, joint author. See under Acker, Hays, Johnson, R.H.
Hartsell, S.E., joint author. See under Acker, R.F.
344. Haugen, Arnold O. and John I. Wear. Response of Lespedeza bicolor to lime, phosphate, and potash. Jour. Wildl. Management 23:456-457. 1959.
Haupt, R.E., joint author. See under Dunham, Tauber.
346. Hawkes, Glenn R. The natural rythm of work, play and rest. Childhood Education 36:304-306. 1960.
347. _____. Current developments and a look ahead in family relations and child development. Jour. Home Econ. 51:573-576. 1959.
_____, joint author. See under Beveridge.

348. Haxby, R.O., L. Jackson Laslett, F.E. Mills, F.L. Peterson, E.M. Rowe, and W.A. Wallenmeyer. Experience with a spiral sector FFAG electron accelerator. Proc. Intl. Conf. on High-Energy Accelerators and Instrumentation. pp. 75-81, 1959. CERN, Geneva, Switzerland.

Hays, H.W., joint author. See under Jørgensen.

349. Hays, V.W., V.C. Speer, P.A. Hartman, and D.V. Catron. The effect of age and supplemental amino acids on the utilization of milk and soya protein by the young pig. Jour. Nutr. 69:179-184. 1959.

_____, joint author. See under Acker, D.C., Aldinger, Frape, Johnsen, C.W., Zimmerman, D.R.

Hazel, L.N., joint author. See under Day.

350. Heady, Earl O. Another look at the farm problem. Iowa Farm Sci. 14(3):3-5. 1959.

351. _____. Feasible criteria and programs. In Problems and Policies of American Agriculture. pp. 204-226. 1st ed. 460 pp. Iowa State Univ. Press, Ames, Iowa.

352. _____. Basic principles in education. Farm Policy Forum pp. 3-8, February, 1960.

353. _____. Labor mobility: A discussion. Amer. Econ. Rev. Proc. 50(2): 413-415. 1960.

354. _____. Iowa State University Center for Agricultural and Economic Adjustment. Iowa Business Digest, pp. 7-16. February, 1960.

355. _____ and Joseph Ackerman. Farm adjustment problems and their importance to sociologists. Rural Sociology 24:316-325. 1959.

356. _____, Ross V. Baumann and Frank Orazem. Adjustments to meet changes in prices and improve incomes on dairy farms in northeast Iowa. Iowa Agric. and Home Econ. Exp. Sta. Res. Bull. 480. 1960.

357. _____ and Walter Butcher. Land retirement. Here's one way to overcome the surplus problem. Iowa Farm Sci. 14(10):3-6. 1960.

358. _____ and Harold O. Carter. Input-output models as techniques of analysis for interregional competition. Jour. Farm Econ. 41:978-991. 1959.

359. _____ and Alvin C. Egbert. Programming regional adjustments in grain production to eliminate surpluses. Jour. Farm Econ. 41:718-783. 1959.

360. _____ and James Gibbons. More about choosing a hog system. Iowa Farm Sci. 14(8):9-11. 1960.

361. _____, John Pesek, and John P. Doll. Production surfaces and economic optima for corn yields with respect to stand and nitrogen levels. Iowa Agric. and Home Econ. Exp. Sta. Bull. 472. 1959.

362. _____, Larry G. Rigler, and Walter Butcher. Who's in the conservation reserve? Iowa Farm Sci. 14(11):3-6. 1960.

363. _____ and Martin H. Yeh. Factors related to the United States and regional demand for fertilizer. Commercial Fertilizer and Plant Food Industry, pp. 32-38. March, 1960.

_____, joint author. See under Barker, Butcher, Carter, Dean, Gibbons, Pesek, Rigler, Smith, W.G., Yeh.

364. Hearn, Walter R. and Richard A. Hendry. The origin of life. Chapter 3 in: Evolution and Christian Thought Today. Wm. B. Erdmans Publ. Co., Grand Rapids, Michigan. 1st ed. 224 pp. 1959.

_____, joint author. See under Duncan.

365. Heath, Harry E. Jr. The mass communication industry and our present manpower crisis. Scholastic Editor 39:10-11. 1960.

_____, Advisory Board. Journalism Quarterly.

366. Heer, John F. Prices of Iowa farm products (1930-1959). Iowa Farm Sci. 14:456. 1960.
_____, Bulletin Editor. Research Publications, Iowa Agricultural and Home Economics Experiment Station.
_____, Editor. Iowa Farm Sci.
Heifner, R., joint author. See under Shepherd.
367. Henderson, P.A. Is your lease fair? Iowa Agric. and Home Econ. Ext. Res. Paper No.261. 12 pp. 1960.
368. Hendrickson, G.O. Fish and game laws. In: Collier's Encyclopedia. Vol. 8, pp.89, 90. P.F. Collier and Son Corp., New York. 1957.
369. _____, J.M. Aikman, M.A. Ellerhoff, H.G. Hershey, F.H. Mendell, E.P. Polder, E.B. Speaker, and G.W. Worley. Report of Committee on Conservation. Proc. Iowa Acad. Sci. 66:55-65. 1959.
Hendry, R.A., joint author. See under Hearn.
370. Herrick, J.B. Livestock disease situation—1960. Iowa Farm Sci. 14(7). 1960.
371. _____ and E.S. Raun. Questions and answers on the use of systemic insecticides for cattle grub control. Iowa Agric. and Home Econ. Ext. Res. Paper No.259. 2 pp. 1959.
_____, joint author. See under Raun.
Hershey, H.G., joint author. See under Hendrickson.
Heseltine, M., joint author. See under Monroe.
Hibbs, E.T., joint author. See under Dahm.
372. Hidlebough, A.R. Variations in Mankato glacial till and related soil types in Hamilton County, Iowa. Proc. Iowa Acad. Sci. 66:272-279. 1959.
373. Higdon, Archie, Edward H. Ohlsen, and William B. Stiles. Mechanics of Materials. 1st ed. 502 pp. John Wiley and Sons, Inc. 1960.
Hill, E., joint author. See under Jennings.
Hill, E.A., joint author. See under Monroe.
374. Hiltrop, Carl L. and John Lemish. Relationship of pore-size distribution and other rock properties to serviceability of some carbonate aggregates. Highway Res. Board Bull. 239. pp.1-23. 1960.
375. _____ and _____. Treatment of carbonate rocks with a vaporous mixture of $(CH_3)_2SiCl_2$ and CH_3SiCl_3. Proc. Iowa Acad. Sci. 66:214-221. 1959.
Hinkebein, J.A., joint author. See under Peterson, D.T.
376. Hinsch, Gertrude Wilma. Alkaline phosphatase of the developing down feather: substrates, activators, and inhibitors. Developmental Biology 2:21-41. 1960.
377. Hippaka, Thomas A. Our automated industrial revolution. Industrial Arts and Vocational Education, pp. 68, 70, 72, 74, 76, 77. May, 1960.
378. _____. Our automated industrial revolution. Industrial Arts and Vocational Education, pp. 38, 42, 44, 45, 46. April, 1960.
379. _____. Our automated industrial revolution. Industrial Arts and Vocational Education. pp.123-128. 1960.
380. _____. Character and spiritual education. Iowa Parent-Teacher. p.12. December, 1959.
381. _____. Our automated industrial revolution. Industrial Arts and Vocational Education, pp.218-220. September, 1959.
Hirst, R.C., joint author. See under Bartell.
Hofstad, M.S., Associate Editor. Avian Diseases.
382. Hogben, David. Test of difference between treatment and control with multiple replications of control and a missing plot. (Answer to query) Biometrics 15:486-487. 1959.

383. Hogrefe, Pearl. The Sir Thomas Moore Circle: A Program of Ideas and their Impact on Secular Drama. 360 pp. Univ. of Illinois Press, Urbana. 1959.

Holland, I.I., joint author. See under Hansen, N.J.

384. Hollander, W.F. Colonic intussusception in the mouse. Amer. Jour. Vet. Res. 20:750-752. 1959.

385. _____. The problem of superfetation in the mouse. Jour. Heredity 50:71-73. 1959.

386. _____, J.H.D. Bryan, and J.W. Gowen. A male-sterile pink-eyed mutant type in the mouse. Fertility and Sterility 11:316-324. 1960.

387. _____ and J.W. Gowen. A single-gene antagonism between mother and fetus in the mouse. Proc. Soc. for Exp. Biol. and Med. 101:425-428. 1959.

388. Holloway, J.T., D.C Lu, and D.J. Zaffarano. Large proportional counter spectrometer for the study of radioactive samples with low specific activity. Rev. Scientific Instruments 31:91-95. 1960.

Holman, R.T., joint author. See under Jørgensen.

389. Holmes, G., I.W. Arthur, H.C. Cook, D.E. Boles, R. Talbot, W. Murray, L. Charity, H. Johnson, and R. Phillips. Action in regard to public institutions. In: Seminar on Adjustment and its Problems in Southern Iowa. Center for Agric. and Econ. Adjust. pp.273-314. 1959.

_____, joint author. See under Morgan.

Homeyer, P.G., joint author. See under Carlin.

390. Hoopes, D.T. Utilization of mayflies and caddisflies by some Mississippi River fishes. Trans. Amer. Fisheries Soc. 89:32-34. 1960.

Hopkins, F.S. Jr., joint author. See under Fedkiw, Duerr.

Horner, T.W., joint author. See under Gates.

391. Horrigan, Virginia M., Velmer A. Fassel, and John W. Goetzinger. Determination of oxygen in yttrium fluoride by a vacuum distillation technique. Anal. Chem. 32:787-789. 1960.

Horton, J.C., joint author. See under Kehr.

392. Hougham, Duane F. Control of oxidative changes in irradiated hams. Food Technology 14:170-172. 1960.

393. Howe, W.L. and G.R. Pesho. Influence of plant age on the survival of alfalfa varieties differing in resistance to the spotted alfalfa aphid. Jour. Econ. Ent. 53:142-144. 1960.

394. Hoyt, Elizabeth E. The four ages of responsibility. Maral (New Delhi) 2A:15-17. 1960.

395. _____. Early welfare: philanthropy in England. Maral (New Delhi) 2(10-12):27-28. 1960.

396. _____. African stories (Development of education in British East Africa). The Negro History Bulletin 23(5):105-111. 1960.

397. _____. Social science research/ fostered by Government in the U.S. Information (Unesco, Paris). 23(60):21-23. 1960.

398. _____. Economic culture adjustment of young Indians. Boletin Indigenista, Mexico City. 20(3):109-119. 1960.

399. _____. The pure flame and the day of wrath. Maral (New Delhi, India) 1(22):7-8. 1960.

400. _____. From a rough people. Maral (New Delhi, India) 2(7-9):5-6. 1960.

401. _____. Voluntary unemployment and unemployability in Jamaica, with special reference to the standard of living. British Jour. of Sociology 40. 1960.

402. _____. Changes in consumer expenditures for food. In: Seminar on Demand for Farm Products, pp.65-66. Iowa State University CAEA Bull. 1959.
403. _____. A new approach to standard of living. The Welfare Reporter (Jamaica) 18(1):29-31, 18(2):27-29, 18(3):12-13. 1959.
405. _____. Changing standard of living in Jamaica. The Caribbean (Trinidad) 13(7):132-133. 1959.
406. _____. Jobs, main concern of Indian teenagers. The Native Voice (Vancouver, B.C.) 13(12):2. 1959.
407. _____. A visit from Mr. K. Mankind (India) 4(4):79-80. 1959.
408. _____. An exploratory project for African libraries. The Library Jour. 84(20):3514-3516. 1959.
409. _____. Economic development in poor countries. Beacon 38(4):124-125. 1959.

_____, American Editor. Maral, New Delhi, India.

410. Hsu, C.T., C.W. Chu, and C.C. Chang. Effect of viscoelastic foundation on forced vibration of loaded rectangular plate. WADD TR60 Air Res. and Develop. Command, USAF, Wright-Patterson Air Force Base, Ohio. 17 pp. April, 1960.

_____, joint author. See under Chang.

Hubbard, E.D., joint author. See under Zimmerman.

411. Hukill, W.V. and J.W. Simons. Aerate stored grain. Electricity on the Farm. December, 1959.

_____, joint author. See under Ives.

412. Hull, Dale O. How to stack baled hay and straw. Agric. Engr. Pamph. 272, May, 1960.
413. _____. Selection and use of spray painting equipment. Agric. Engr. Pamphlet 266. March, 1960.
414. Hunt, Donnell R. Farm Power and Machinery Management. 3rd ed. 190 pp. Iowa State University Press, Ames. 1960.

Hunziker, R.R., joint author. See under Scott.

Hurlburt, V., joint author. See under Duncan, E.R.

415. Hutchcroft, C.D., J.L. Robinson, and R.L. Ingledue. The 1959 Iowa corn yield test. Iowa Agric. and Home Econ. Extension Pamphlet No.128, 20 pp. 1960.

Hutchinson, M., joint author. See under Burrill.

Ignatieff, V., joint author. See under Pesek.

Ingledue, R.L., joint author. See under Hutchcroft.

416. Isely, Duane. Laboratory mixing and dividing of grass seed mixtures. Proc. Assoc. Official Seed Analysts 49:56-62. 1959.
417. _____ and L.N. Bass. Seeds and packaging materials. Proc. Hybrid Corn Industry, Res. Conf. 14:101-110. 1959.
418. _____ and S.L. Welsh. Petalostemon candidum and P. occidentale (Leguminosae). Brittonia 12:114-118. 1950.
419. Ives, Norton C. and W.V. Hukill. How grain dries. Successful Farming September, 1959.
420. _____, _____, and R.A. Saul. Grain ventilation and drying patterns. Trans. Amer. Soc. Agric. Engr. 2(1):95-101. 1959.

421. Jackson, B.B. and A.C. MacKinney. Methods for determining training needs. Personnel, pp.60-68. Sept/Oct, 1959.

Jackson, Bill C., joint author. See under Wenkert.

Jackson, R.D., joint author, See under Peters.
Jacobson, N.L., joint author. See under Hartman, Johnson, R.H.
Jarvie, A.W., joint author. See under Gilman.
Jasinski, R.J., joint author. See under Fassel.

422. Jebe, Emil H. On a quail roadside count technique. (Answer to Query) Biometrics 15:629-631. 1959.

_____, joint author. See under Beveridge, Schmidt.

423. Jennings, L.D., E. Hill, and F.H. Spedding. The heat capacity of samarium from 13° to 350°K. Jour. Chem. Physics 31:1240-1243. 1959.

_____, joint author. See under Stanton, Vossos.

424. Jensen, Jo Ann S., H. Nadine Petersen, and Oscar E. Tauber. Confirmation by culture and staining methods of absence of symbiotic flora in Tribolium confusum Duval. Jour. Econ. Entomol. 52:756-757. 1959.

Jensen, C.R., joint author. See under Phillips.
Jensen, E.N., joint author. See under Daniel.

425. Jessen, Raymond J. Encuesta por muestreo de las fincas en la provincia de Buenos Aires, Aires, Argentina. Estadistica 16:464-504. 1958.

_____, joint author. See under Bryant.

426. Johnsen, R.E., P.A. Dahm, H.W. Rusk, M.L. Fairchild, and A.E. Freeman. Heptachlor residues on corn stover in relation to dairy cattle feeding. Jour. Econ. Entomology 53:19-22. 1960.

427. Johnson, C.W., V.C. Speer, V.W. Hays, and D.V. Catron. Thyroprotein for lactating cows. Jour. Anim. Sci. 18:1224-1232. 1959.

428. Johnson, H.P. Water supplies in Southern Iowa. In: Seminar on Adjustment and its Problems in Southern Iowa. Center for Agric. and Econ. Adjust. Report 4. 7 pp. 1959.

_____, joint author. See under Holmes, Ligon, Shrader.
Johnson, I.J., joint author. See under Thompson, L.M.

429. Johnson, R.H., P.A. Hartman, L.R. Brown, H.H. Van Horn, Jr., and N.L. Jaconson. Sustained prevention of bloat by antibiotics fed in rotation or in combination. Report of the Fifth Conf. on Rumen Function pp. 29-30. 1960.

430. _____, _____, _____, _____, and _____. Ibid. Jour. Anim. Sci. 18: 1500-1501. 1959.

_____, joint author. See under Hartman.
Jordan, M.N., joint author. See under Monroe.

431. Jørgensen, E.A., E.E. Leppik, H.W. Hayes, and R.T. Holman. Essential fatty acid deficiency II. In adult rats. Jour. Nutrition 66(2):245-259. 1958.

Jurgenson, H., joint author. See under O'Byrne.

Kaldor, D., joint author. See under Shepherd.

432. Kalton, R.R. Seed production problems in isolated recombination blocks. Agron. Jour. 51:535-537. 1959.

433. _____, R.A. DeLong, and D.S. McLeod. Cultural factors in seedling vigor of smooth bromegrass and other forage species. Iowa State Jour. Sci. 34:47-80. 1959.

_____, joint author. See under Christie.

434. Karas, George G. and V.H. Denenberg. Effects of differential infantile handling upon weight gain and mortality in the rat and mouse. Science 130:629-630. 1959.

Karraker, Shirley K., joint author. See under Fritz.

Kato, H., joint author. See under Deardorff.

435. Katti, S.K. Moments of the absolute difference and absolute deviation of discrete distributions. Annals of Math. Stat. 31:78-85. 1960.

436. Kehr, A.E. and James C. Horton. Resistance of potato in infections by mechanically introduced virus X. Amer. Potato Jour. 37:61-66. 1960.

437. Kempthorne, Oscar. Biometrical relations between relatives and selection theory. In: Biometrical Genetics. Pergamon Press, London and New York. 1960. 234 pp.

_____, joint author. See under Nordskog, Peperzak, Zyskind.

_____, Editor. Biometrical Genetics, Pergamon Press.

_____, Editorial Board. Biometrics.

_____, Associate Editor. The Annals of Mathematical Statistics.

438. Kenkel, William F. Traditional family ideology and spousal roles in decision making. Marriage and Family Living 21:334-339. 1959.

439. _____. The Family in Perspective: A Fourfold Analysis. 1st ed. 472 pp. Appleton-Century-Crofts, Inc. 1960.

_____, joint author. See under Cameron.

_____, Associate Editor. Alpha Kappa Deltan.

Kilp, G.R., joint author. See under Chiotti.

King, R.W., joint author. See under DePuy.

440. Kirkham, Don. Exact theory of flow into a partially penetrating well. Jour. Gelphysical Res. 64:1317-1327. 1959.

441. _____. Review of Drainage Investigations and Design. Republic of Turkey, Ministry of Public Works, Ankara and T.A.M.S. Engineers, New York. 113 pp. 1959.

442. _____. Letter to Editor (Einstein, Lorentz and Relativity). Amer. Scientist 47:232A-236A. 1959.

443. _____. Seepage into ditches from a plane water table overlying a gravel substratum. Jour. Geophysical Res. 65:1267-1272. 1960.

_____, joint author. See under Nielsen, Phillips.

_____, Consulting Editor. Soil Science.

Kittrell, F.P., joint author. See under Monroe.

444. Klonglan, Eugene D., Russell L. Robbins, Bromfield L. Ridley. Evaluation of effectiveness of pheasant flushing bars in Iowa hayfields. Proc. Iowa Acad. Sci. 66:534-552. 1959.

445. Kniseley, R.N., V.A. Fassel, and E.E. Conrad. Observations on the silicon-hydrogen vibrational bands in alkyl and aryl substituted silanes. Spectrochimica Acta 15:651-655. 1959.

_____, joint author. See under Gray.

446. Kolmer, Lee. Hog marketing in Iowa. Iowa State Univ. Coop. Ext. Serv. M-919. 29 pp. 1959.

447. _____ and Joseph Gartner. Consumer marketing handbook II. Cereal products. Iowa State Univ. Ext. Serv. Bull. 24 pp. 1960.

448. _____, _____, and Francis A. Kutish. Consumer marketing handbook I. Meat. Iowa State Univ. Ext. Serv. Bull. 48 pp. 1960.

Kontrimas, R., joint author. See under Peterson, D.T.

449. Kratochvil, Byron and Harvey Diehl. The determination of cobalt by oxidation with potassium molybdicyanide. Talanta 3:346-350. 1960.

450. Krause, K. and R.R. Beneke. What hog system for you? Iowa Farm Sci. 14(5). 1959.

Krausz, N.G.P., joint author. See under O'Byrne.

Kuetemeyer, Carol A., Assistant Bulletin Editor. Research Publications, Iowa Agricultural and Home Economics Experiment Station.

_____, Associate Editor. Iowa Farm Science.

451. Kunau, Emedda. Today's girl—home furnishings. Iowa State University Bull. C-4178. 44 pp. 1960.
452. Kutish, F.A. Farm Outlook. (A column). Iowa Farm Sci. Vols. 1-12. 1959-60.
_____, joint author. See under Kolmer, Shepherd, Wakeley.

453. Ladd, George W. Trends in state margarine legislation. Jour. Marketing 24:65-69. 1960.
454. _____. A statistical analysis of certain institutional variables in the butter and margarine market. Iowa Agric. and Home Econ. Exp. Sta. Res. Bull. R 474. 25 pp. 1960.
455. Langenhop, C.E. Note on almost periodic solutions of non-linear differential equations. Jour. Math. and Physics 38:126-129. 1959.
456. Larsen, J.A. Some pioneers and leaders in American forestry and conservation. Iowa State Jour. Sci. 34:521-544. 1960.
457. Larson, W.E., W.G. Lovely, J.T. Pesek, and R.E. Burwell. Effect of subsoiling and deep fertilizer placement on yields of corn in Iowa and Illinois. Agron. Jour. 52:185-189. 1960.
_____, joint author. See under Lovely, Van Wijk.
_____, Associate Editor. Soil Science Society of America Proceedings.
458. Laslett, L. Jackson and K.R. Symon. Computational results pertaining to use of a time-dependent magnetic field perturbation to implement injection or extraction in a FFAG synchrotron. Proc. Internatl. Conf. on High-Energy Accelerators and Instrumentation. pp. 38-47. CERN, Geneva, Switzerland. 1959.
_____, joint author. See under Hammer, Haxby.
459. Lathwell, D.J., J.T. Cope, Jr., and J.R. Webb. Liquid fertilizers as sources of phosphorus for field crops. Agron. Jour. 52:251-254. 1960.
Laursen, M., joint author. See under Fuller.
Lawrence, W.W., joint author. See under Duke.
Lee, Alice, joint author. See under French.
Lee, I., joint author. See under Dahm.
Legvold, S., joint author. See under Curry, Hill, Liu.
Lemish, Jane, joint author. See under Lemish, John.
460. Lemish, John and Ramon E. Bisque. Autoclave method for determining susceptibility of carbonate aggregates to silicification. Proc. Iowa Acad. Sci. 66:210-213. 1959.
461. _____ and Jane Lemish. Jeff Carson, Young Geologist. 1st ed. 211 pp. Dodd, Mead and Company. 1960.
_____, joint author. See under Bisque, Hiltrop.
462. Leppik, E.E. Cercospora traversiana and some other pathogens of fenugreek new to North America. Plant Dis. Reptr. 44(1):40-44. 1960.
463. _____. Some viewpoints on the phylogeny of rust fungi III. Origin of grass rusts. Mycologia 51(4):512-528. 1959.
464. _____. Newest achievements in the study of the "languages of bees." Amer. Bee Jour. 100(1):22-24. 1960.
_____, joint author. See under Jørgensen.
465. Lessel, Erwin F. Jr. Status of the generic name Mycobacterium Lehmann and Neumann. Internatl. Bull. Bact. Nomen. and Taxon. 10:47-54. 1960.
466. _____. The nomenclatural status of the generic names of the Actinomycetales. Internatl. Bull. Nomen. and Taxon. 10:87-192. 1960. (Suppl.)

Leverton, Ruth, joint author. See under Acker, D.C., Burrill.
Lewis, E.C., joint author. See under Reed.
Lichtenwalter, G.D., joint author. See under Gilman.
467. Lichtwardt, R.W. and G.L. Barron. A quantitative deterioration rating scale for shelled corn. Iowa State Jour. Sci. 34:139-146. 1959.
_____, joint author. See under Barron.
Lieberman, F.V., joint author. See under Pesho.
Lifson, N., joint author. See under Thompson, A.M.
468. Ligon, J.T. and H.P. Johnson. Infiltration capacities of Fayette silt loam from analysis of hydrologic data. Trans. Amer. Soc. Agric. Engr. 3(1):36-37. 1960.
Lilly, J.H., joint author. See under Long.
Liston, Margaret, joint author. See under Duncan, E.R.
469. Liu, S.H., D.R. Be rendt, S. Legvold, and R.H. Good, Jr. Interpretation of the magnetic properties of dysprosium. The Physical Rev. 116:1464-1468. 1959.
Lockhart, W.R., joint author. See under Acker, Beers, Ecker, Raun.
_____, Assistant Section Editor. Biological Abstracts.
Loeffel, F.A., joint author. See under Sass.
470. Long, W.H. and J.H. Lilly. Effects of chemical seed treatments on wireworm activities. Jour. Econ. Entomol. 52:509-511. 1959.
Loomis, B.A., joint author. See under Carlson, O.N.
471. Lommis, W.E. La photosynthèse - Base de la vie. Scientia 94. 1959.
472. _____, R. Santamaria-P., and R.S. Gage. Cohesion of water in plants. Plant Physiol. 35:300-306. 1960.
_____, joint author. See under Ansari, Schieferstein.
_____, Editor, Section on Plant Physiology. Biological Abstracts.
473. Lovely, W.G., G.R. Free, and W.E. Larson. Preparing the seedbed. Chapter 15 in: U.S.D.A. Yearbook of Agriculture. 1960.
474. _____ and D.W. Staniforth. Granular herbicide formulations for weed control in corn. Proc. North Central Weed Control Conf. 16:53-54. 1959.
_____, joint author. See under Larson, Rowe, Schmidt, Staniforth.
Lu, D.C., joint author. See under Stewart, Holloway.
Lyons, C.E., joint author. See under DePuy.
475. Lundvall, R.L. Clinical use of succinylcholine chloride in the horse. Vet. Med. 55:42-43. 1960.
476. Lush, Jay L. Improving dairy cattle by breeding 1. Current status and ourlook. Jour. Dairy Sci. 43:702-706. 1960.
477. Lyle, Mary S. Home and family life education. Chapter 40 in: Handbook of Adult Education in the United States. 624 pp. Adult Education Assoc. of the U.S.A. 1960.
478. _____. Educational needs of three socio-economic groups of rural homemakers in Iowa. Iowa Agric. and Home Econ. Res. Bull. 470. pp. 543-568. 1959.
479. Lynch, David W. Midwest solid-state physics conference. In: Physics Today 13(4):40-42. (A conference report) 1960.

480. MacDonald, G.B. and George W. Thomson. Professor George Bernhardt Hartman (A biography). Iowa State Jour. Sci. 34:505-506. 1960.
481. MacKinney, A.C. What should ratings rate? Personnel pp. 75-78. May/June, 1960.
482. _____ and Leroy Wolins. Selection of clerical workers. Personnel Psychology 12. 1959.
_____, joint author. See under Jackson, B.

MacVicar, R., joint author. See under Acker, D.C.

483. Magnusson, Jon R. and L.G. Hammond. The separation of glycerides by crystallization in a thermal gradient. Jour. Amer. Oil Chem. Soc. 36:339-343. 1959.

484. Mahlstede, John P. Graft failures in apple stions. Proc. Plant Propagators Soc., 8th Ann. Meet. 8:153-158. 1959.

485. _____ and W.E. Fletcher. Storage of nursery stock. Bull. Amer. Assoc. of Nurserymen, in cooperation with Iowa Agric. and Home Ec. Exp. Sta. 60 pp. 1960.

_____, Editor. Proceedings Plant Propagators Society.

486. Mahmoud, Hormoz. Angular distribution of polarized electrons emitted from oriented nuclei. Annals of Physics 7:429-439. 1959.

487. Maki, Wilbur R. Book Review: An econometric investigation of city land market prices, by Pentti Pöyhömen. Econometrica 27:728-729.

488. _____. Iowa's livestock marketing pattern. Natl. Livestock Producer 38:11, 30. 1960.

489. _____. Forecasting beef cattle and hog prices by quarter-years. Iowa Agric. and Home Econ. Exp. Sta. Res. Bull. 473. 1959.

_____, joint author. See under Gaardner, Thompson, S.H.

Mandel, S.P.H., joint author. See under Scheuer.

Mangel, M., joint author. See under Burrill.

490. Manzer, F.E. Potato meristem culture and virus X. Amer. Potato Jour. 36:191-195. 1959.

Manzo, E.Y., joint author. See under Eshelman.

Marcus, S., joint author. See under Eshelman.

491. Martin, Elwood M. Wood ducks: twilight travelers. Iowa Conservationist 18:163-164. 1959.

Martin, D.S., Jr., joint author. See under Dunning.

492. Martin, N.F.G. A note on metric density of sets of real numbers. Proc. Amer. Math. Soc. 11:344-347. 1960.

493. Mathews, J.C. and B. Vinograde. Note on the classical canonical form of a matrix. Amer. Math. Monthly 67:68-70. 1960.

Mathews, J., joint author. See under Zimmermann.

494. Matzinger, D.F., G.F. Sprague, and C.C. Cockerham. Diallel crosses of maize in experiments repeated over locations and years. Agron. Jour. 51:346-350. 1959.

495. Mauldon, R.G. and John L. Dillon. Droughts, fodder reserves and stocking rates. Australian Jour. Agric. Econ. 3:45, 57. 1959.

_____, joint author. See under Dillon.

McComb, A.L., joint author. See under Shaw

496. McCann, J.A. Life history studies of the spottail shiner of Clear Lake, Iowa, with particular reference to some sampling problems. Trans. Amer. Fisheries Soc. 88:336-343. 1960.

McComb, A.P., joint author. See under Schaller, Wakeley.

McDaniels, J.C., joint author. See under DePuy.

497. McDonnell, P.M., F.J. Stevenson, and J.M. Bremner. Release of fixed ammonium from soil by ball milling. Nature 183:1414-1415. 1959.

498. McKeown, Donald. A new home—inside and out. Successful Farming 58(9):58-61, 101. 1960.

McKeown, J.J., joint author. See under Spedding.

McLeod, D.S., joint author. See under Kalton.

McLeod, H.E., joint author. See under Barnes.

499. McNabb, H.S., Jr. Host-parasite interactions in woody-plant vascular diseases. Proc. Western Int. For. Dis. and Work Conf. 6:26-33. 1958.

Medrud, R.C., joint author. See under Atoji.

500. Meinwald, J. and O.L. Chapman. The conversion of scopinone into meta-hydroxybenzaldehyde. Jour. Amer. Chem. Soc. 81:5800-5803. 1959.

Melampy, R.M., joint author. See under Day, Duncan.

_____, Reviewer. Journal of Animal Science.

Mendell, F.H., joint author. See under Henrickson.

Mendoza, C., joint author. See under George.

501. Metzler, David E. Thiamine coenzymes. Chapter 9 in: The Enzymes. 2nd ed. Academic Press. 1960.

502. Meyer, F.P. and M.J. Ulmer. Studies on the cestode genus Marsipometra Cooper (Pseudophyllidea : Amphicotylidae). Jour. Parasitology 45(4):29-30. 1959.

Michel, L.J., joint author. See under Simons.

503. Mickey, M.R. Some finite population unbiased ratio and regression estimators. Jour. Amer. Stat. Assoc. 54:594-612. 1959.

Miller, G.A., joint author. See under Utterback.

Mills, F.E., joint author. See under Haxby.

Minturn, R.E., joint author. See under Hansen, R.S.

Mitchell, E.N., joint author. See under Pohm.

Moldenhauer, W.C., joint author. See under Shrader.

504. Monroe, D., D.D. Scott, L.K. Addis, B.I. Coon, E. Eppright, R. Frisbie, M. Heseltine, E.A. Hill, M.N. Jordan, F.P. Kittrell, B. Paolucci, E. Scudder, E.W. Scully, I. Sperry, and M. Suydam. Home economics new directions—a statement of philosophy and objectives. Amer. Home Econ. Assoc. 14 pp. 1959.

505. Morford, Vilas J. Farm and Dairy Mechanics. 8th ed. 149 pp. Burgess Publishing Co. 1959.

506. Morgan, Barton, Glenn Holmes, and Clarence Bundy. Methods in Adult Education. 1st ed. 180 pp. The Interstate Printers and Publishers. 1960.

Morris, Eula, joint author. See under Acker, D.C.

507. Muncy, R. Jess. Age and growth of channel catfish from the Des Moines River, Boone County, Iowa, 1955 and 1956. Iowa State Jour. Sci. 34:127-137. 1959.

508. Murphy, Glenn. Nature and properties of materials—a discussion of the report of ASEE follow-up subcommittee on materials. Amer. Soc. for Testing Materials, Tech. Publ. No.263. pp.37-42. 1959.

509. Murphy, Glenn, and Robert E. Uhrig. Observations on creep of tantalum. Ames Lab. Res. and Develop. Report, U.S.A.E.C. 30 pp. 1959.

_____, joint author. See under Stuart.

Murphy, H.C., joint author. See under Frey.

Murray, W., joint author. See under Holmes.

Murteira, B., joint author. See under Tintner.

510. Myers, R.E. and R.H. Shaw. Estimation of consecutive dry days at Ames and Corydon, Iowa. Iowa State Jour. Sci. 34:1-9. 1959.

Myoda, T., joint author. See under Baugh.

Nasrat, M.E., joint author. See under Wakeley.

Nelson, F.W., joint author. See under Royer.

511. Newman, D.E. Factors influencing the winter roadside count of cottontails. Jour. Wildlife Mgt. 23:290-294. 1959.

Nicholson, R.P., joint author. See under Pesek.

512. Nichter, A.M., J.H. Coolidge, J.C. O'Byrne, and G.B. Whitman. Income tax management for farmers. Iowa Agric. and Home Econ. Ext. Res. Paper No.264. 12 pp. 1960.
513. Nielsen, D.R., Don Kirkham, and E.R. Perrier. Soil capillary conductivity: comparison of measured and calculated values. Soil Sci. Amer. Proc. 24:157-160. 1960.
514. _____, _____, and W.R. van Wijk. Measuring water stored temporarily above the field moisture capacity. Soil Sci. Soc. Amer. Proc. 23: 408-412. 1959.

Nielsen, V., joint author. See under Wakeley.

515. Niira, Kazuo. The temperature dependence of the magnetization of dysprosium metal. Physical Rev. 117:129-133. 1960.
516. Norden, A.J. and K.J. Frey. Factors associated with lodging resistance in oats. Agron. Jour. 51:535-538. 1959.

_____, joint author. See under Frey.

517. Nordskog, A.W. Importance of egg size and other factors in determining net income in random sample tests. Poultry Sci. 39:327-338. 1960.
518. _____. Note on optimum group size for progeny tests. Biometrics 15:513-517. 1959.
519. _____ and O. Kempthorne. Importance of genotype-environment interactions in random sample poultry tests. In: Biometrical Genetics. Pergamon Press, London and New York. 1960.
520. _____ and R.E. Phillips. Heterosis in poultry 5. Reciprocal crosses involving Leghorns, heavy breeds and Fayoumi. Poultry Sci. 39: 257-263. 1960.
521. _____, L.T. Smith, and R.E. Phillips. Heterosis in poultry 2. Crossbreds vs. top crossbreds. Poultry Sci. 38:1372-1380. 1959.

_____, joint author. See under Goto.

_____, Associate Editor. Poultry Science.

522. Norton, Don C. Effect of combinations of pathogenic organisms at different temperatures on the cotton seedling disease. Texas Agric. Exp. Sta. Misc. Publ. 412:1-2. 1960.

523. O'Byrne, J.C., N.G.P. Krausz, N.E. Harl, and H. Jurgenson. The farm corporation. Iowa Agric. and Home Econ. Ext. Res. Paper No.273. 20 pp. 1960.

_____, joint author. See under Harl, Nichter.

524. Odetoyinbo, J.A. and M.J. Ulmer. Studies on avian filarial worms of the subfamily Splendido filariinae (Nematoda:Dipetalonematidae). Jour. Parasitology 45(4):58. 1959.

Oest, I., joint author. See under Wakeley.

Ogawa, I.A., joint author. See under DePuy.

525. Ogg, Wallace E. Iowa—a state in economic and social transition—agricultural problems and prospects. Iowa Business Digest 30(12): 1959.
526. _____. Foreign agricultural policy and the European market. In: Increasing Understanding of Public Problems and Policies. Farm Foundation, Chicago. pp.51-60. 1959.

_____, joint author. See under Duncan, E.R.

Ohlsen, E.H., joint author. See under Higdon.

Ohlson, M.A., joint author. See under Burrill.

Orazem, F., joint author. See under Heady.

527. Orgell, W.H., E.W. Hamilton, E.T. Hibbs, and O.V. Carlson. Cholinesterase inhibitory compounds occurring naturally in potatoes, Solanum tuberosum (L.) and their possible relationship to leafhopper, Empoasca fabae (Harris) resistance. Entomol. Soc. Amer., North Central Branch Proc. 14:5. 1959.
528. _____, Kunda A. Vaidya, and Eugene W. Hamilton. A preliminary survey of some midwestern plants for substances inhibiting human plasma cholinesterase in vitro. Proc. Iowa Acad. Sci. 66:149-154. 1959.
529. _____, _____ and _____. Biosynthesis of cholinesterase-inhibitory substances from non-inhibitory dialkyl thiophosphates by plant tissues. Proc. Iowa Acad. Sci. 66:145-148. 1959.
_____, joint author. See under Dahm.
530. O'Toole, Lela, N. Brumbaugh, H. LeBaron, C. Tucker, and Pearl Swanson. Home economics in land-grant colleges and universities. A statement of objectives and future directions. 14 pp. 1960.
531. Owings, W.J. and S.L. Balloun. Relation of arginine and lysine to feather tyrosinase activity. Poultry Sci. 38:1285-1289. 1959.
_____, joint author. See under Balloun.

Packer, R.A., Reviewer. American Journal of Veterinary Research.
Page, H.J., joint author. See under Pesek.
Pangborn, R.M., joint author. See under Carlin.
Paolucci, B., joint author. See under Monroe.
532. Parker, D.T. and W.C. Burrows. Root and stalk rot in corn as affected by fertilizer and tillage treatment. Agron. Jour. 51:414-417. 1959.
Parks, G., joint author. See under Duncan, E.R.
Pasto, D.J., joint author. See under Chapman.
Paulsen, A., joint author. See under Futrell, Shepherd.
533. Pavelis, G.A. and J.F. Timmons. Linear programming: a new tool for watershed planning. Jour. Soil and Water Conservation 15:5-10. 1960.
534. Pease, Damaris. About children's physical growth. Iowa Farm Sci. 14(2): 1959.
535. Peckham, John C., John S. Guldner, Richard L. Winegarden. The "lungworm" Filaroides milksi, in Iowa dog. The Iowa State Univ. Vet. 22:129-131. 1960.
Pedersen, John H., Managing Editor. Swine Equipment Plans.
_____, Managing Editor. Sheep Equipment Plans.
536. Penny, L.H. Improving combining ability by recurrent selection. Proc. 14th Annual Hybrid Corn Industry Res. Conf. 14:7-11. 1959.
537. _____ and F.F. Dicke. European corn borer damage in resistant and susceptible dent corn hybrids. Agron. Jour. 51:323-326. 1959.
_____, joint author. See under Sprague.
538. Peperzak, Paul. Correlation of selected soil indices with plant growth on highway backslopes. Iowa Hwy. Res. Board Bull. No.10. 130 pp. 1959.
539. _____, A.G. Caldwell, R.R. Hunziker, and C.A. Black. Phosphorus fractions in manures. Soil Sci. 87:293-302. 1959.
540. _____, W.D. Shrader, and Oscar Kempthorne. Correlation of selected soil indices with plant growth on highway backslopes in Iowa. In: Highway Res. Board Proc. 38th Ann. Meeting. 1959.
Perrier, E.R., joint author. See under Nielsen.

541. Pesek, John T., Earl O. Heady, John P. Doll, and R.P. Nicholson. Production surfaces and economic optima for corn yields with respect to stand and nitrogen levels. Iowa Agric. and Home Econ. Exp. Sta. Res. Bull. 472. 1959.
542. _____ and V. Ignatieff. Factors affecting the use of fertilizers and manures. Chapter 5 in: Efficient Use of Fertilizers. Food and Agriculture Organization of the United Nations No.43. 355 pp. 1958.
543. _____ and H.J. Page. Time and method of fertilizer application in efficient use of fertilizers. Food and Agriculture Organization of the United Nations No.43. 355 pp. 1958.

_____, joint author. See under Duncan, E.R., Heady, Larson, Shrader, Thompson, L.M., Webb.

544. Pesho, G.R. and F.V. Lieberman. A biotype of the spotted alfalfa aphid on alfalfa. Jour. Econ. Ent. 53:146-150. 1960.

_____, joint author. See under Howe.

545. Peters, Don C. and R.D. Jackson. The effect of dwarf corn on European corn borer infestations. Proc. North Central Branch, Entomol. Soc. Amer. 14:5-6. 1959.

_____, joint author. See under Browning, George, Grogan.

Petersen, H.N., joint author. See under Jensen.

546. Peterson, D.T. Effect of hydrogen on tensite and impact properties of thorium. Metallurgical Soc. Conf. on Reactive Metals 2:477-485. 1959.
547. _____ and D.J. Beerntsen. The uranium-hafnium equilibrium system. Trans. Amer. Soc. for Metals 52:763-777. 1960.
548. _____ and J.A. Hinkebeir. Equilibria in the reaction of barium with calcium chloride. Jour. Physical Chem. 63:1360-1364. 1959.
549. _____ and R. Kontrimas. Distribution of silver between liquid lead and zinc. Jour. Physical Chem. 64:362-365. 1960.
550. _____ and D.G. Westlake. The rate of reaction of hydrogen with thorium. Jour. Physical Chem. 63:1514-1517. 1959.
551. _____ and _____. Diffusion of hydrogen in thorium. Jour. Physical Chem. 64:649-652. 1960.
552. _____, _____ and J. Rexer. The effect of thorium oxide on thorium-hydrogen equilibrium. Jour. Amer. Chem. Soc. 81:4443-4445. 1959.

Peterson, F.L., joint author. See under Haxby.

Peterson, D.J., joint author. See under George, Gilman.

Peterson, N.C., joint author. See under Duke.

553. Peterson, Peter A. Linkage of fruit shape and color genes in Capsicum. Genetics 44:407-419. 1959.
554. _____. The pale green mutable system in maize. Genetics 45:115-133. 1960.

Petr, F., joint author. See under Frey.

Pfaeffle, W.D., joint author. See under Dahm.

555. Phillips, Richard. Cost of procuring, manufacturing and distributing mixed feeds in the midwest. U.S.D.A. Marketing Res. Rept. No.338. 76 pp. 1960.
556. _____. How to make a five-year plan. Hatchery and Feed 34(3):31-34. 1960.
557. _____. What happens when you cut your poultry prices. Turkey Producer edition, Amer. Poultry Jour. 91(5):20-21. 1960.
558. _____. A modern concept of the economic structure in cooperative associations. In: Extension and research workshops in farmer cooperative. pp.10-19. Amer. Inst. of Cooperation, Washington, D. C. 1959.

559. _____, Richard. Modern management in American cooperation—1959. pp. 134-140. American Institute of Cooperation, Washington, D.C. 1959.
_____, Contributing Editor. Farm Store Merchandising.
560. Phillips, R.E., C.R. Jensen, and Don Kirkham. Use of radiation equipment for plow-layer density and moisture. Soil Sci. 89:2-7. 1960.
_____, joint author. See under Balloun, Nordskog, Holmes.
561. Pickett, Mary. Evaluating storage and counter space. Jour. Home Econ. 52:36-37. 1960.
562. _____. Kitchen cabinets—for convenience and appearance. Iowa Farm Sci. 14:855-858. 1960.
563. _____. Plan management into kitchen storage and counter space. Iowa Farm Sci. 14:15-18. 1959.
Pierre, W.H., Consulting Editor. Soil Science.
_____, Consulting Editor. Agronomy Journal.
Pietrzyk, D.J., joint author. See under Fritz.
564. Pohl, R.W. Introduced weedy grasses in Iowa. Proc. Iowa Acad. Sci. 66:160-162. 1959.
565. _____. Morphology and cytology of some hybrids between Elymus canadensis and E. virginicus. Proc. Iowa Acad. Sci. 66:155-159. 1959.
566. _____ and James P. Gillespie. Distributional and cytological notes on Salsola collina. Rhodora 61:265-267. 1959.
567. Pohm, A.V. and E.N. Mitchell. Magnetic film memories, a survey. 1960 International Solid State Circuits Conf. Digest of Technical Papers. 1st ed. pp.20-21. 1960.
568. _____, A.A. Read, R.M. Stewart, Jr., and R.F. Schauer. Operation of magnetic film parametrons in the 100 to 500 Mc regions. Jour. Appl. Physics Supple. 31(5):119s-120s. 1960.
569. _____, A.A. Read, R.M. Stewart, Jr., R.F. Schauer. High frequency magnetic film parametrons for computer logic. Proc. Natl. Electronics Conf. 15:202-214. 1959.
_____, joint author. See under Read.
Polder, E.P., joint author. See under Hendrickson.
571. Pond, Julia. How convenient is your kitchen. Iowa Farm Sci. 14:10-13. 1959.
Ponder, B.W., joint author. See under DePuy.
Pope, L.S., joint author. See under Acker, D.C.
572. Porter, Arthur R. Length of gestation of Brown Swiss cattle. Brown Swiss Bull. 38(10):14. 1960.
573. _____. Soilage feeding for dairy cows. Guernsey Breeders' Jour. 105(8):692-693, 711. 1960.
Powell, R.D., joint author. See under Tamsma.
574. Preston, R.L. and W. Burroughs. Physiological actions of diethylstilbestrol in lambs fed varying levels of protein and energy. Jour. Appl. Physiol. 15:97-100. 1960.
Pritchard, S., joint author. See under Charles.
575. Pudelkewicz, Cecelia and Charlotte Roderuck. Pantothenic acid deficiency in the young guinea pig. Jour. Nutrition 70:348-352. 1960.
Purnell, G., joint author. See under Fuller.

576. Quinn, L.Y., R.D. Wilbur, and Damon V. Catron. In vitro response of Candida albicans and Candida tropicalis to antifungal agents. Antibiotics and Chemotherapy 10:95-100. 1960.
_____, joint author. See under Acker, R.F., Speer, Wilbur.

Ralston, R.A., joint author. See under Conover.
Ramsey, F.K., joint author. See under Bowne.
577. Rao, J.N. Some sampling methods in forest surveys. Indian Forester (India) 85:723-727. 1959.
578. _____. A note on mean square successive differences. Jour. Amer. Stat. Assoc. 54:801-806. 1959.
Raun, A., joint author. See under Burroughs.
579. Raun, E.S. External parasites of sheep. Iowa Agric. and Home Econ. Ext. Res. Paper No.180. 2 pp. 1959.
580. _____ and John B. Herrick. Organophosphate systemics as sprays and feed additives for cattle grub control. Jour. Econ. Entomology 53: 125-126. 1960.
581. _____, William R. Lockhart, and Russell J. Beers. Microorganisms found in field specimens of diseased corn borer larvae. Proc. Iowa Acad. Sci. 66:508-512. 1959.
_____, joint author. See under Beers, George, Gunderson, Herrick, Stockdale.
Raun, Ned, joint author. See under Burroughs.
582. Read, A.A. and A.V. Pohm. Magnetic film parametric amplifier. Proc. Natl. Electronics Conf. 15:65-78. 1959.
_____, joint author. See under Pohm.
583. Reed, Woodrow W., Edwin C. Lewis, and Leroy Wolins. Differential interest patterns of engineering graduates. The Personnel and Guidance Jour. 38:571-573. 1960.
584. Rehder, Dudley Dean. Some aspects of the life history of the carp, Cyprinus carpio, in the Des Moines River, Boone County, Iowa. Iowa State Jour. Sci. 34:11-26. 1959.
585. Renaud, Ray E. Evaluation of glue line quality by block shear, plywood shear and gross-lap test specimens. Iowa State Jour. Sci. 34:713-730. 1960.
Rexer, J., joint author. See under Peterson, D.T.
Richard, J.J., joint author. See under Banks.
Richards, A.B., joint author. See under Shepherd.
586. Richards, D.O. and T.A. Bancroft. Statistical quality control programs in manufacturing. Engr. Ext. Bull. No.131. 35 pp. Iowa State Univ. 1960.
587. Richardson, C.E., A.B. Watts, W.S. Wilkinson, and J.M. Dixon. Techniques used in metabolism studies with surgically modified hens. Poultry Sci. 39:432-439. 1960.
588. Richter, Donald L. and Seymour Geisser. A statistical model for diagnosing zygosis by ridge-count. Biometrics 16:110-114. 1960.
589. Ridenhour, Richard L. Development of a program to sample young fish in a lake. Trans. Amer. Fisheries Soc. 89:185-192. 1960.
Ridley, B.L., joint author. See under Klonglan.
590. Riecken, F.F. Some trends in the higher category classification of alluvium-derived soils. Jour. Indian Soil Sci. Soc. 7(4):199-205. 1959.
_____, joint author. See under Ryan, Shrader, Smith, S.M., Soileau.
591. Rigler, L.G., E.O. Heady, and W. Butcher. Who's in the conservation reserve? Iowa Farm Sci. 14(11). 1960.
_____, joint author. See under Heady.
Riley, J.A. Jr., joint author. See under Wallin.
592. Rising, James S. and Carl A. Arnbal. Engineering Graphics Problem Book 3. 1st ed. 54 pp. Wm. C. Brown Book Co., Dubuque, Iowa. 1960.
593. Roan, J.E., M. Harris, and J.F. Timmons. Land contract or mortgage? Iowa Farm Sci. 14(5). 1959.

Robbins, R.L., joint author. See under Klonglan.

594. Roberson, Opal and Elsie K. Williams. Look your best—a well-groomed woman. Iowa Agric. and Home Econ. Ext. Res. Paper No.HE-42. 8 pp. 1959.

595. Roberts, Eliot Collins. Caution on "short cuts" for lawns. Iowa Farm Sci. 14(10):8-11. 1960.

596. _____. Go for a better lawn. Iowa Farm Sci. 14(11):10-13. 1960.

597. _____, M.C. Shurtleff, and H. Gunderson. Stop lawn pests. Iowa Farm Sci. 14(12):3-6. 1960.

Roberts, H., joint author. See under Burrill.

Robinson, J.L., joint author. See under Hutchcroft.

598. Robotka, F. What is a cooperative? Iowa Inst. of Cooperation, Ames, Iowa. Project 1255. 1959.

599. _____. Capper-Volstead and the co-operatives. Jour. Farm Econ. 41(5):1213-1223. 1959.

Roderuck, Charlotte, joint author. See under Pudelkewicz, Eppright, Gschneidner.

600. Rogers, E.M. and G.M. Beal. Projective techniques and rural respondents. Rural Sociol. 24:178-182. 1959.

601. _____ and _____. Projective techniques: potential tools for agricultural economists? Jour. Farm Econ. 41:644-648. 1959.

602. Rohweder, Dwayne A. Introducing science to youth. Ext. Ser. Rev., USDA Federal Ext. Serv. 30:176. 1959.

603. Rose, M.E. and R.H. Good, Jr. Angular distribution of recoils from mu meson capture. Annals of Physics 9:211-219. 1960.

_____, joint author. See under Good.

Rosenberg, S.D., joint author. See under Gilman.

Rosenfeld, Louise, joint author. See under Duncan, E.R.

Roth, Dale, Assistant Editor. Farm Policy Forum.

Roth, F.W., joint author. See under Hull.

604. Rothenbuhler, Walter C. A technique for studying genetics of colony behavior in honey bees. Amer. Bee Jour. 100:176, 198. 1960.

_____, joint author. See under Craig.

_____, Science Editor. American Bee Journal.

Rowe, E.M., joint author. See under Haxby.

605. Rowe, R.J. and W.G. Lovely. Side-band attachment made for Lister planter. Crops and Soils 12:23. 1960.

606. Royer, Kieth. Protective clothing for volunteers. The Volunteer Firefighter 7(3):5-6. 1959.

607. _____ and Floyd W. Nelson. Water for fog fire fighting. Fire Engr. 112(8):670, 811. 1959.

_____, Editor. Fire Service Information.

608. Ruch, R.J. and L.S. Bartell. Wetting of solids by solutions as a function of solute adsorption. Jour. Physical Chem. 64:513-519. 1960.

_____, joint author. See under Bartell.

609. Ruedenberg, Klaus. Boulder Conference on molecular quantum mechanics. Physics Today 13(5):34-36. 1960.

610. Ruhe, R.V. and W.H. Scholtes. Important elements in the classification of the Wisconsin glacial stage. Jour. Geology 67:585-593. 1959.

Rundle, R.E., joint author. See under Atoji, Fitzwater, Vossos.

_____, Editorial Board. Journal of Physical Chemistry.

611. Rush, Wilbur A., George Wilkinson, and Thomas A. Barton. Guide for county conservation boards. Iowa State Conserv. Comm. 1st ed. 153 pp. 1959.

Rusk, H.W., joint author. See under Johnsen, R.E.

612. Russell, Glen A. Catalysis by metal halides. I. Mechanism of the disproportionation of ethyltrimethylsilane. Jour. Amer. Chem. Soc. 81:4815-4825. 1959.
613. _____. Catalysis by metal halides. II. The disproportionation of trimethylsilane, phenyltrimethylsilane and bromotrimethylsilane. Jour. Amer. Chem. Soc. 81:4825-4831. 1959.
614. _____. Catalysis by metal halides. III. The question of the existence of siliconium ions. Jour. Amer. Chem. Soc. 81:4831-4833. 1959.
615. _____. Catalysis by metal halides. IV. Relative efficiency of Friedel-Crafts catalysts in cyclohexane-methylcyclohexane isomerization, alkylation of benzene and polymerization of styrene. Jour. Amer. Chem. Soc. 81:4834-4838. 1959.
616. _____. Solvent effects in the reactions of free radicals and atoms. VI. Separation of polar and resonance effects in the reactions of chlorine atoms. Tetrahedron 8:101-106. 1960.

Russell, W.A., joint author. See under Sprague.

617. Ryan, Pierce, S.M. Smith, and F.F. Riecken. Extent of the Muscatine Series in Muscatine County, Iowa. Proc. Iowa Acad. Sci. 66:257-262. 1959.

618. Sabey, B.R., L.R. Frederick, and W.V. Bartholomew. The formation of nitrate from ammonium nitrogen in soils: III. Influence of temperature and initial population of nitrifying organisms on the maximum rate and delay period. Soil Sci. Soc. Amer. Proc. 23:462-465. 1959.
619. Sadanaga, K. and M.D. Simons. Transfer of crown rust resistance of diploid and tetraploid species to hexaploid oats. Agron. Jour. 52: 285-288. 1960.
620. Sanderson, D.E. Isotopy in 3-manifolds II. Fitting homeomorphisms by isotopy. Duke Math. Jour. 26:387-396. 1959.
621. _____. Isotopy in 3-manifolds III. Connectivity of spaces of homeomorphisms. Proc. Amer. Math. Soc. 11:171-176. 1960.

Santamaria-P, R., joint author. See under Loomis.

622. Sass, John E. and Frank A. Loeffel. Development of axillary buds of maize in relation to barrenness. Agron. Jour. 51:484-486. 1959.
623. Saul, Robert A. Principles of grain drying. Feedstuffs, Sept. 12, 1959.

_____, joint author. See under Ives.

624. Schaller, F.W., K.K. Barnes, W D. Shrader, J.M. Scholl, and A.P. McComb. Land use and crop production potentials and alternatives. In: Seminar on Adjustment and its Problems in Southern Iowa. Center for Agric. and Econ. Adjustment 4:151-179. 1959.

_____, joint author. See under Duncan, E.R., Shrader.

Schauer, R.F., joint author. See under Pohm.

Schenk, G.H., joint author. See under Fritz.

625. Scheuer, P.A.G. and S.P.H. Mandel. An inequality in population genetics. Heredity 13:519-524. 1959.
626. Schieferstein, R.H. and W.E. Loomis. Development of the cuticular layers in angiosperm leaves. Amer. Jour. Botany 46:625-635. 1959.

Schirber, J.E., joint author. See under Atoji.

627. Schlebecker, John T. The world metropolis and the history of American agriculture. Jour. Econ. History 20:187-208. 1960.

Schmidt, F.A., joint author. See under Carlson, O.N.

628. Schmidt, J.L. and Emil H. Jebe. The effect of artificial drying on the yield of head rice and the germination of rice. Trans. Amer. Soc. Agric. Engr. 2:26-31. 1959.

629. _____ and W.G. Lovely. Report on effects of corn topping. U.S.D.A. ATS-42-35. 10 pp. 1959.
630. Schmulbach, James C. Growth of the walleyes in the Des Moines River, Boone County, Iowa. Proc. Iowa Acad. Sci. 66:523-533. 1959.
631. Schneider, E.M., A.L. Walker, and H.E. Childs. The Range of Literature. 1st ed. 732 pp. American Book Co. 1960.
Scholl, J.M., joint author. See under Schaller.
Scholtes, W.H., joint author. See under Ruhe.
632. Schroeder, P.J. and M.J. Ulmer. Host parasite relationships of Spirorchis elegans Stunkard (Trematoda:Spirorchidae). Proc. Iowa Acad. Sci. 66:443-454. 1959.
Schuck, C., joint author. See under Burrill.
Schupp, G., joint author. See under Daniel.
633. L.H. Schwarte. Out present knowledge of reservoirs and vectors of hog cholera virus. Proc. 63rd Ann. Meet. U.S. Livestock Sanitary Assn. pp. 317-322. 1959.
_____, joint author. See under Biester.
634. Schwenk, Lillian Casler. Age and fatal motor vehicle accidents. Hwy. Res. Board Bull 212. Natl. Acad. Sci., Washington, D.C. pp. 21-27. 1959.
635. Scott, A.D., A.P. Edwards, and J.M. Bremner. Removal of fixed ammonium from clay minerals by cation exchange resins. Nature 185:792. 1960.
636. _____, R.R. Hunziker, and J.J. Hanway. Chemical extraction of potassium from soils and micaceous minerals with solutions containing sodium tetraphenylboron I. Preliminary experiments. Soil Sci. Soc. Amer. Proc. 24:191-194. 1960.
_____, joint author. See under Welch.
Scott, D.D., joint author. See under Monroe.
Scudder, E., joint author. See under Monroe.
Scully, E. W., joint author. See under Monroe.
Segel, S.L., joint author. See under Barnes, R.G.
637. Seifert, George. Almost periodic solutions for systems of differential equations near points of nonlinear first approximation. Amer. Math. Soc. Proc. 11:429-435. 1960.
Sell, J.L., joint author. See under Balloun.
Senne, J.H., joint author. See under Carr.
638. Serovy, George K. and E.W. Anderson. Method for predicting off-design performance of axial-flow compressor blade rows. Natl. Electronics and Space Admin. Tech. Note D-110. 37 pp. 1959.
639. Shah, B.V. On a 5 x 2^2 factorial design. Biometrics 16:115-118. 1960.
640. _____. A generalisation of partially balanced incomplete block designs. Annals of Math. Stat. 30:1041-1050. 1959.
641. _____. A matrix substitution method of constructing partially balanced designs. Annals of Math. Stat. 31:34-42. 1960.
642. _____. Corrections to "On balancing in factorial experiments." Annals of Math. Stat. 30:1267. 1959.
643. _____. Balanced factorial experiments. Annals Math. Stat. 31:502-514. 1960.
644. Shaw, R.H. and E.R. Duncan. Crop yield prospects for 1960. Iowa Farm Sci. 14(7):7-8. 1960.
645. _____ and A.L. McComb. A comparison of the Gunn-Bellani radiation integrator and the Eppley pyrheliometer. Forest Sci. 5:234-236. 1959.
_____, joint author. See under Denmead, Elford, Myers, Thompson, L.M.

646. Sheeler, J.B. Sodium chloride stabilized roads in Iowa. Proc. Hwy. Res. Board 39. 1960.
647. Shepherd, Geoffrey. What's happening to our food consumer? Iowa Farm Sci. 14(3). 1959.
648. _____. United States District Court for the Eastern District of Kentucky. Julian G. Rogers et al. vs. United States of America. Testimony of Geoffrey Shepherd. U.S. Court of Appeals for the 6th Circ. 14,086: 296a-227a. 1959.
649. _____. Discussion: Revisions of the parity index. Jour. Farm Econ. 41:1302-1306. 1959.
650. _____, Francis Kutish, Don Kaldor, Richard Heifner, and Arnold Paulsen. Storage and supports have worked, but. . . Iowa Farm Sci. 14:7-9. 1959.
651. _____, Arnold Paulsen, and Donald Kaldor. A barometer of free farm prices. Co-op Grain Quart. Natl. Fed. Grain Coops. 18:7-13. 1960.
652. _____, _____, Francis Kutish, Don Kaldor, Richard Heifner, and Gene Futrell. Production, price and income estimates and projections for the feed-livestock economy under specified control and market-clearing conditions. Iowa State Univ. Bull. 60 pp. 1960.
653. _____, Allen Richards, and John Wilkin. The grain storage picture. Iowa Farm Sci. 14(11). 1960.
654. _____, _____ and _____. Some effects of federal grain storage programs on grain storage capacity, grain stocks and country elevator operations. Purdue Univ. Reg. Res. Bull. 1960.
655. _____ and Kurt Ullrich. Our corn-hog-cattle belt. Iowa Farm Sci. 14:5-6. 1960.
_____, joint author. See under Duncan, E.R., Fuller.
656. Shideler, Emerson W. Can science and theology converse? The Christian Century 77:215-217. 1960.
657. Shrader, W.D., Howard Johnson, Laurel Ericson, and Don Gray. What can you expect from irrigation? Iowa Farm Sci. 14(8):7-8. 1960.
658. _____, John Pesek, and W.C. Moldenhauer. What about continuous corn? Iowa Farm Sci. 14(9):3-5. 1960.
659. _____, F.W. Schaller, J.R. Pesek, D.F. Slusher, and F.F. Riecken. Estimated crop yields on Iowa soils. Agric. and Home Ec. Exp. Sta. Spec. Rept. No.25. pp.1-23. 1960.
_____, joint author. See under Peperzak, Shaller.
660. Shurtleff, M.C. Plant disease outlook for 1960. Iowa Farm Sci. 14(7). 1960.
_____, joint author. See under Cott, Roberts, Thompson, H.E.
Sidles, P.H., joint author. See under Wallace.
Sidwell, V.D., joint author. See under Eppright.
Simons, J.W., joint author. See under Hukill.
661. Simons, M.D. Variability among strains of noncultivated species of Avena for reaction to races of the crown rust fungus. Phytopathology 49:598-601. 1959.
662. _____ and L.J. Michel. Physiologic races of crown rust of oats identified in 1958. Plant Dis. Reptr. 43:1010-1012. 1959.
_____, joint author. See under Sadanaga.
_____, Editor. Phytopathology.
Singh, R.S., joint author. See under Banks.
Slusher, D.F., joint author. See under Shrader.
Smith, C.F., joint author. See under Collins, Diehl.
664. Smith, Elbert B. Thomas Hart Benton. Colliers' Encyclopedia. 1960.

665. Smith, Elbert B. Blair - Francis Preston, Francis Preston, Jr., and Montgomery Blair. Colliers' Encyclopedia. 1960.
666. _____. Samuel Philips Lee. Colliers' Encyclopedia. 1960.
667. _____. Review of Robert Rayback, Millard Fillmore. Miss. Valley Hist. Rev. 46:518-519. 1960.
668. _____. Francis P. Blair and the Globe: nerve center of Jacksonian Democracy. The Register (Kentucky Hist. Soc.) 57:340-353. 1959.
669. Smith, G. Frederick and Harvey Diehl. The wet oxidation of bone. Digestion with 100 per cent sulfuric acid followed by the addition of dioxonium perchlorate. Talanta 3:41-45. 1959.
670. _____ and _____. Anhydrous magnesium perchlorate desiccant with added indicator. Talanta 3:107. 1959.
_____, joint author. See under Diehl, H.
671. Smith, J.F. and C.L. Arbogast. Elastic constants of single crystal beryllium. Jour. Appl. Physics 31:99-102. 1960.
672. _____ and J.L. Christian. Thermodynamics of formation of copper-magnesium and nickel-magnesium compounds from vapor pressure measurements. Acta Mettalurgica 8:249-255. 1960.
673. _____ and J.A. Gjevre. Elastic constants of yttrium single crystals in the temperature range 4.2-400°K. Jour. Appl. Physics 31:645-647. 1960.
674. _____ and J.D. Greiner. Magnetic susceptibility of thorium metal in the range 130-300°K. The Physical Rev. 115:884-885. 1959.
Smith, L.T., joint author. See under Nordskog.
675. Smith, Omar E. and G.T. York. Moths of the European corn borer infected with the fungus, Beauveria bassiana (Balsamo) Vuillemin. Jour. Insect Pathol. 2:196-197. 1960.
Smith, R.C., joint author. See under Goetz.
Smith, R.V., joint author. See under Banks.
Smith, S.G., joint author. See under Drury.
676. Smith, Shirley Jean. Today's Girls—Clothing Book I. Iowa State Univ. C-4200. 48 pp. 1960.
677. Smith, Sanford M. and Frank F. Riecken. Soil survey, Jefferson County, Iowa. U.S. Govt. Prtg. Off. 62 pp. 1960.
_____, joint author. See under Ryan.
678. Smith, Wesley G. and Earl O. Heady. Use of a dynamic model in programming optimum conservation farm plan on Ida-Monona soils. Iowa Agric. and Home Econ. Exp. Sta. Res. Bull. 475. 1960.
_____, joint author. See under Heady.
Smutz, M., joint author. See under Wakeley.
Soddy, T.S., joint author. See under Gilman.
679. Soileau, J.M. and F.F. Riecken. Profile characteristics of some forest-formed soils derived from Iowan till. Proc. Iowa Acad. Sci. 66:263-269. 1959.
Speaker, E.B., joint author. See under Hendrickson.
680. Spedding, F.H., J.J. McKeown, and A.H. Daane. High temperature thermodynamic functions of cerium, neodymium and samarium. Jour. Physical Chem. 64:289-294. 1960.
_____, joint author. See under Carlson, O.N., Curry, Hall, Jennings, Stanton.
681. Speer, Vaughn C., Herbert Brown, Loyd Quinn, and Damon Catron. The cessation of antibody absorption in the young pig. Jour. Immunology 83:632-634. 1959.
_____, joint author. See under Aldinger, Frape, Hays, Johnson, C.W., Wilbur, Zimmerman, D.R.

Sperry, I., joint author. See under Monroe.

682. Sprague, G.F., W.A. Russell, and L.H. Penny. Mutations affecting quantitative traits in the selfed progeny of doubled monoploid maize stocks. Genetics 45:855-866. 1960.

683. _____, _____ and _____. Recurrent selection for specific combining ability and type of gene action involved in yield heterosis in corn. Agron. Jour. 51:392-394 1959.

684. _____, _____, and _____. Further studies on convergent improvement in corn. Genetics 44:341-346. 1959.

_____, joint author. See under Gutierrez, Matzinger.

685. Stacy, W.H. What can you do for community improvement? Iowa Farm Sci. 14(1). 1959.

Stadelman, W.J., joint author. See under Card.

Stahl, Nancy L., Editorial Assistant. Research Publications, Iowa Agricultural and Home Economics Experiment Station.

686. Staley, H. Gene and Harry J. Svec. The determination of nitrogen in metals by isotope dilution. Analytica Chimica Acta 21:289-295. 1959.

_____, joint author. See under Svec.

687. Staniforth, D.W. and W.G. Lovely. Comparisons of granular and liquid formulations of 2,4-D under various simulated rainfall conditions. Proc., North Central Weed Control Conf. 16:54. 1959.

688. _____, E.P. Sylwester, and Walter G. Lovely. Weed control in corn. Iowa State Univ. Coop. Ext. Serv. Pamphlet 269. 8 pp. 1960.

689. _____, _____, C.R. Weber and W.G. Lovely. Weed control in soybeans. Iowa State Univ. Coop. Ext. Serv. Pamphlet 270. 4 pp. 1960.

_____, joint author. See under Lovely.

_____, Editorial Committee. Weeds. Journal of the Weed Society of America.

691. Stanton, R.M., L.D. Jennings and F.H. Spedding. The heat capacity of terbium from 1.4° to 4.0° Kelvin. Jour. Chem. Physics 32:630-631. 1960.

Steudel, W., joint author. See under Gilman.

Stevenson, F.J., joint author. See under McDonnell.

692. Stewart, M.G. and D.C. Lu. Nuclear levels of Cs^{133}. Physical Rev. 117:1044-1051. 1960.

_____, joint author. See under Clikeman.

Stewart, R.M. Jr., joint author. See under Carr, Pohm.

Stiles, W.B., joint author. See under Higdon.

693. Stockdale, Harold J. and Earle S. Raun. Economic importance of the chicken body louse. Jour. Econ. Entomology 53:421-423. 1960.

Story, P.R., joint author. See under DePuy.

Stout, N., joint author. See under Fedkiw.

694. Strain, J. Robert. A report on cow pools in Iowa. Indiana State Dairy Assn. 70th Ann. Rept. 70:12-19. 1959.

695. _____. Cow pools, a step toward integration? Iowa Farm Sci. 14(4): 3-4. 1959.

696. _____. Keeping in step. Extension Serv. Rev. 3(11):243-246. 1959.

Strand, N.V., joint author. See under Gaardner.

697. Strohbehn, R.W. and J.F. Timmons. Who owns Iowa's farms? Iowa Farm Sci. 14(5). 1959.

698. _____ and _____. Changing paths to farm ownership. Iowa Farm Sci. 14(9). 1960.

699. _____ and _____. How do owners get their farms? Iowa Farm Sci. 14(6). 1959.

700. Stuart, D.O. and Glenn Murphy. Prediction of critical pressures for the two-phase flow of saturated water in pipes. Amer. Soc. Mech. Engr. Paper No. 58-A-112. 8 pp. 1959.

Sunde, M.L., joint author. See under Card.

Suydam, M., joint author. See under Monroe.

701. Suzuki, I. and C.H. Werkman. Glutathione reductase of Thiobacillus thiooxidans. Biochem. Jour. 74:359-362. 1960.

702. Svec, Harry J. and H. Gene Staley. The determination of nitrogen in metals by isotope dilution. Anal. Chim. Acta 21:289-295. 1959.

_____, joint author. See under Staley.

Swanson, L.E., joint author. See under Card.

703. Swanson, Pearl. Food energy and the metabolism of nitrogen. Chapter 8, pp. 195-224, In: Protein and Amino Acid Nutrition. Academic Press. 2nd ed. 1959.

704. _____. Nutritional needs after 25. Food. The Year Book of Agriculture, 1959, U.S.D.A.

705. _____. Nutrition research - Home economics' unique contribution. Amer. Home Ec. Assn. Symposium. 25 pp. 1959.

_____, joint author. See under Burrill.

_____, Editorial Committee. California Agricultural Experiment Station, Bull. N.C. 769. 131 pp. 1959.

Swenson, C.A., joint author. See under Atoji, Beecroft.

706. Switzer, William P. Action of certain viruses, Mycoplasma hyorhinis, and nasal trichomonads on swine tissue cultures. Amer. Jour. Vet. Res. 20:1010-1019. 1959.

Sylwester, E.P., joint author. See under Aikman, Saniforth.

Symon, K.R., joint author. See under Laslett.

Talbot, R., joint author. See under Holmes.

707. Tamsma, A. and R.D. Powell. Evaluation of Lea's aldehyde determination method. Agric. and Food Chem. 7:643-646. 1959.

708. Tauber, Oscar E., Robert E. Haupt, and Delma E. Harding. Elementary Physiology - A Laboratory Guide. The MacMillan Company 1st ed. 190 pp. 1960.

_____, joint author. See under Jensen.

Theurer, B., joint author. See under Burroughs.

709. Thielman, H.P. Translator of: On estimates of the solutions of systems of differential equations of the accumulation of disturbances and stability of motion over a finite time interval. By: Chzhan Sy-In. Jour. Appl. Math. and Mech. 23(4):920-933. 1959.

710. _____. Translator of: Asymptotic integration of linear partial differential equations with small principal part. By: A.L. Col'denveizer. Jour. Appl. Math. and Mech. 23(1):44-74. 1959.

711. _____. Translator of: Asymptotic solutions of nonlinear second order differential equations with variable coefficients. By: G.E. Kuzmak. Jour. Appl. Math. and Mech. 23(3):730-744. 1959.

712. _____. Translator of: Oscillations of a quasilinear nonautonomous system with one degree of freedom near resonance. By: A.P. Proskuriakov. Jour. Appl. Math. and Mech. 23(5):1218-1232. 1959.

713. _____. Translator of: Model illustrating some properties of a hardening plastic body. By: Iu. N. Rabotnov. Jour. Appl. Math. and Mech. 23(1):219-228. 1959.

714. _____. Translator of: The pressure on an elastic half-space of a stamp with wedge-shaped planform. By: V.L. Rvachev. Jour. Appl. Math. amd Mech. 23(1):229-232. 1959.

715. _____. Translator of: Solution of a dynamic problem with mixed boundary conditions in the theory of elasticity for a half-plane. By: V.A. Sveklo. Jour. Appl. Math. and Mech. 23(2):381-393. 1959.

716. Thoma, John A., Henry B. Wright, and Dexter French. Partiaion chromatography of homologous saccharides on cellulose columns. Arch. Biochem. and Biophys. 85:452-460. 1959.

Thomas, W.I., joint author. See under Eldredge.

717. Thompson, Alan M. and E.B. Brown, Jr. Tissue carbon dioxide concentrations in rats during acute respiratory acidosis. Jour. Appl. Phys. 15:49-52. 1960.

718. _____, H. Mead Cavert, Nathan Lifson, and Robert L. Evans. Regional tissue uptake of D_2O in perfused organs: rat liver, dog heart and gastrocnemius. Amer. Jour. Physiology 197:897-902. 1959.

Thompson, D.J., joint author. See under Jessen.

719. Thompson, H.E., E.R. Duncan, W.H. Bragonier, and M.C. Shurtleff. Seed outlook and crop varieties for 1960. Iowa Farm Sci. 14(7). 1960.

720. Thompson, Leon E. The farm problem—return to a free market? Iowa Farm Sci. 14(10):16-18. 1960.

721. _____. The farm problem—eat up or export the surplus? Iowa Farm Sci. 14(8):12-14. 1960.

722. _____. The farm problem—what's behind it? Iowa Farm Sci. 14(6):12-14. 1959.

_____, Assistant Editor. Iowa Agricultural and Home Economics Extension Service.

723. Thompson, L.M., I.J. Johnson, J.T. Pesek, Jr., and R.H. Shaw. Some causes of recent high yields of feed grains. Proc. Iowa State Coll. Feed-Livestock Workshop, Special Rept. 24, pp.15-37. 1959.

724. Thompson, Sam H. and Wilbur R. Maki. How we market our livestock . . . the trends. Iowa Farm Sci. 14:315-317. 1959.

725. Thomson, George W. and Glenn H. Dietschman. Bibliography of world literature on the Bitterlich method of plotless cruising. Iowa State Univ. and Home Econ. Exp. Sta. No. F-160. 1959.

_____, joint author. See under MacDonald.

726. Thorbecke, Erik. Discussion paper of L. Witt, "Increasing the Foreign Demand for Farm Products. Iowa Center for Agric. and Econ. Adj. Report No.2 on Demand for Farm Products. pp.62-63. 1959.

727. _____. Review of L'Echange International by Michel Moret. Econometrica 27(3):519-521. 1959.

728. _____. The tendency towards regionalization in international trade, 1928-1956. Martinus Nijhoff. The Hague. 1st ed. 223 pp. 1960.

Timmons, J.F., joint author. See under Harl, Pavelis, Roan, Strohbehn.

729. Tintner, G. The use of mathematics in econometrics and economic statistics. (in Arabic), translated by Dr. Ibrahim Hilmy Abd-al-Rahman. In: Readings in the Social Sciences, No.1. Social Sciences Section, UNESCO. Middle East Science Coop. Office, Cairo, Egypt. pp.105-124. 1958-59.

730. _____. The application of decision theory of probability to a simple inventory problem. Trabajos de Estadistica 10:239-247. 1959.

731. _____ and Bento Murteira. Um modelo 'input-output' simplificado para e economia portuguesa. In: Colectanea de Estudos, No.8, Centro de Estudos de Estatística Económica. Lisbon Portugal. 14 pp. 1960.

732. _____. A note on stochastic linear programming. Econometrica 28:490-495. 1960.
733. _____. Review of: Lineare Planungsrechnung (Linear Programming). by: Martin J. Beckman. Ludwigshafen am Rhein 1959. Fachverlag für Wirtschaftstheorie x,118 S. Kyklos 12:511-513. 1959.
734. _____. Review of: Probleme der statistischen Methodenlehre in den Sozialwissenschaften. By: Oskar Anderson. 2., wesentlich umgearb. u. erw. Aufl. (Einzelschriften der Deutschen Statistischen Gesellschaft, Nr.6.) Würzburg 1957. Physica-Verlag. VIII, 358 S. DM 24, 50. Weltwirtschaftliches Archiv. 84(2):96*-97*. 1960.
735. _____. Review of: Jan Tinbergen Selected Papers. Edited by L.H. Klaassen, L.M. Koyck, H.J. Witteveen. Amsterdam: New Holland Publ. Co., 1959. 318 pp. Amer. Econ. Rev. 50:170-171. 1960.
_____, Associate Editor and Book Review Editor. Econometrica.
_____, Associate Editor. Metroeconomica.
_____, Associate Editor. Unternehmungsforschung.
_____, Abstractor. Mathematical Reviews.
736. Town, George R. Professionalism vs. unionism. Jour. Engr. Educ. 50:671-672. 1960.
737. _____. The television allocations study organization—a summary of its objectives, organization and accomplishments. Proc. Inst. Radio Engr. 48:993-999. 1960.
Trenkle, A., joint author. See under Burroughs.
738. Trusell, Fred and Harvy Diehl. Phenyl-2-pyridyl ketoxime, a reagent for iron in strong alkalies. A method for determining oxidized iron in the presence of metallic iron. Anal. Chem. 31:1978-1980. 1959.

Uhrig, R.E., joint author. See under Murphy.
Ullrich, K., joint author. See under Shepherd.
739. Ulmer, M.J. Avian schistosomes of the genus Ornithobilharzia at Lake Okoboji. Jour. Parasitology 45(4):19. 1959.
_____, joint author. See under Meyer, Schroeder, Odetoyinbo.
740. Utterback, N.G. and G.A. Miller. Ionization yields for fission fragments. Physical Rev. 116:976-980. 1959.

Vaidya, K.A., joint author. See under Orgell.
741. Vance, Ben A. How to plant a rose. Iowa Agric. and Home Econ. Ext. Res. Paper No.267. 4 pp. 1960.
742. _____. How to air-layer a house plant. Iowa Agric. and Home Econ. Ext. Res. Paper No.268. 4 pp. 1960.
Van Diest, A., joint author. See under Dos Santos.
Van Horn, H.H., Jr., joint author. See under Johnson, R.H.
743. Van Wijk, W.R., W.E. Larson, and W.C. Burrows. Soil temperature and the early growth of corn from mulched and unmulched soil. Soil Sci. Soc. Amer. Proc. 23:428-434. 1959.
_____, joint author. See under Nielsen.
744. Van Zante, Helen J. What about electronic ranges? Iowa Farm Sci. 14:15-17. 1959.
Vinograde, B., joint author. See under Mathews.
745. Vossos, P.H., L.D. Jennings, and R.E. Rundle. On the structure and magnetic properties of $LiCuCl_3 \cdot 2H_2O$. Jour. Chem. Physics 32:1590-1591. 1960.

746. Wakeley, Ray E. (Chairman), J.M. Bohlen, F. Carlin, F. Kutish, A. McComb, V. Nielsen, I. Oest, M. Smutz, and R. Beneke. Action communities can take which will assist in the development of Southern Iowa. C.A.E.A. Report No.4, Seminar on adjustment and its problems in southern Iowa. pp.263-272. 1959.

747. Wakeley, Ray E. and Mohiey Eldin Nasrat. Sociological analysis of population migration. Rural Sociological Soc. Vol. 25. 1960.

Walker, A.L., joint author. See under Schneider.

748. Walker, H.W. and J.C. Ayres. Characteristics of yeast isolated from processed poultry and the influence of tetracyclines on their growth. Appl. Microbiol. 7:251-255. 1959.

749. _____ and _____. Microorganisms associated with commercially processed turkeys. Poultry Sci. 38:1351-1355. 1959.

750. _____, William J. Coffin and John C. Ayres. A resazurin reduction test for the determination of microbiological quality of processed poultry. Food Technol. 13:578-581. 1959.

751. Wallace, D.C., P.H. Sidles, and G.C. Danielson. Specific heat of high purity iron by a pulse heating method. Jour. Appl. Physics 31:168-176. 1960.

Wallace, F.G., joint author. See under Clark.

Wallenmeyer, W.A., joint author. See under Haxby.

752. Wallin, Jack R. and John A. Riley, Jr. Weather map analysis—an aid in forecasting potato late blight. Plant Dis. Reptr. 44:227-234. 1960.

Ward, P., joint author. See under Weller.

Warner, R.F., joint author. See under Assinacopoulos.

Watts, A.B., joint author. See under Richardson.

Wear, John I., joint author. See under Haugen.

753. Webb, John R. and John T. Pesek. An evaluation of phosphorus fertilizers varying in water solubility: II. Broadcast applications for corn. Soil Sci. Soc. Amer. Proc. 23:381-284. 1959.

_____, joint author. See under Lathwell.

754. Weber, C.R. Crop management - soybeans. Iowa State Univ. Press. The Midwest Farm Handbook 5th ed. 237 pp. 1960.

755. _____ and M.G. Weiss. Chlorophyll mutant in soybeans provides teaching aid. Jour. Heredity 50:53-54. 1959.

_____, joint author. See under Gates, Staniforth.

_____, Publications Board. Iowa Farm Science.

Weiss, M.G., joint author. See under Weber.

Welsh, S.L., joint author. See under Isely.

756. Welch, L.F. and A.D. Scott. Nitrification in nutrient solutions with low levels of potassium. Canadian Jour. Microbiol. 5:425-430. 1959.

757. Weller, Milton W. Albinism in Podiceps grisegena and other grebes. Auk 76:520-521. 1959.

758. _____. Parasitic egg laying in the redhead (Aythya americana) and other North American anatidae. Ecological Monographs 29:333-365. 1959.

759. _____ and P. Ward. Migration and mortality of hand-reared redheads (Aythya americana). Jour. Wildl. Mgmt. 23:427-433. 1959.

_____ Editorial Associate. Journal of Wildlife Management.

760. We[illegible]ert. Review of: Infrared absorption spectra of steroids. An atlas. By: C. Roberts, B.S. Gallagher, and R.N. Jones. Spectrochimica Acta 16:397. 1960.

761. _____. Steric effects in chemical reactions. Chapter in: The McGraw-Hill Encyclopedia of Science and Technology. McGraw-Hill Book Co., Inc. 1st ed. 1960.

762. _____ and John H. Hanson. Some reactions of gelsemine. Iowa State Jour. Sci. 34:163-174. 1959.

763. _____ and Bill G. Jackson. Hydrophenanthrenecarboxylic esters. Jour. Amer. Chem. Soc. 81:5601-5605. 1959.
Werkman, C.H., joint author. See under Baugh, Suzuki.
_____, Collaborator. Enzymologia.
Westlake, D.G., joint author. See under Peterson, D.T.
Wheat, J.G., joint author. See under Browning.
764. Wheelock, T.D. and D.R. Boylan. Reductive decomposition of gypsum by carbon monoxide. Industrial and Engineering Chem. 52:215-218. 1960.
_____, joint author. See under Bethea.
White, W.C., joint author. See under Gilkey.
Whiteman, J.V., joint author. See under Acker, D.C.
Whitman, G.B., joint author. See under Nichter.
765. Wiggans, S.C. Responses of oat plants to various percentages of continuous shade. Botanical Gazette 121:55-60. 1959.
766. _____ and F.P. Gardner. Effectiveness of various solutions for simulating drouth conditions as measured by germination and seeding growth. Agron. Jour. 51:315-318. 1959.
767. Wilbur, R.D., D.V. Catron, Loyd Y. Quinn, and Vaughn C. Speer. Intestinal flora of the pig as influenced by diet and age. Jour. Nutr. 71:168-175. 1960.
_____, joint author. See under Quinn.
Wilcox, R.A., joint author. See under Ballantyne.
Wilder, D.R., joint author. See under Wirkus.
768. Wilhelm, H.A. Development of uranium metal production in America. Jour. Chem. Educ. 37:56-68. 1960.
Wilkin, J.T., joint author. See under Shepherd.
Wilkinson, G., joint author. See under Rush.
Wilkinson, W.S., joint author. See under Richardson.
Williams, D.E., joint author. See under Atoji.
Williams, Elsie K., joint author. See under Robinson.
769. Willrich, T.L. and E.R. Baumann. Quality and treatment of pond water. Trans. ASAE, Special Soil and Water Edition 3(1):1-8. 1960.
Wilsie, C.P., joint author. See under Beveridge, J.L., Hart.
Winegarden, R.L., joint author. See under Peckham.
Winkler, H.J.S., joint author. See under Gilman.
Winter, A.R., joint author. See under Card.
770. Winter, Dorothy M. The development of the seed of Abutilon theophrasti I. Ovule and embryo. Amer. Jour. Botany 47:8-14. 1960.
771. _____. The development of the seed of Abutilon theophrasti II. Seed coat. Amer. Jour. Botany 47:157-162. 1960.
772. Wirkus, C.D. and David R. Wilder. Uranium glass. I. Fundamental considerations. Atomic Energy Comm. Rept. No.IS-107. pp.1-19. 1960.
773. Wittenberg, D., M.V. George, and H. Gilman. Cleavage reactions of some organopolysilanes. Jour. Amer. Chem. Soc. 81:4812-4815. 1959.
774. _____ and H. Gilman. Organosilylmetallic compounds: their formation and reactions and comparison with related types. Quart. Rev. 13: 116,145. 1959.
775. _____, T.C. Wu, and H. Gilman. Reaction of triphenylsilyllithium and triphenylsilylpotassium with benzaldehyde. Jour. Organic Chem. 24:1349-1351. 1959.
_____, joint author. See under Gilman, Wu.
Wolf, E., joint author. See under Duke.

776. Wolins, Leroy. Needed: publication of negative results. Amer. Psychol. 14:598. 1959.
777. _____. An improved procedure for the Wherry-Winer method for factoring large numbers of items. Psychometriks 24:261-264. 1959.
_____, joint author. See under Reed, MacKinney.
Woods, W., joint author. See under Burroughs, Davison.
778. Woolley, D.G. and W.H. Bennett. Glutamic acid content of sugar beets as influenced by soil moisture, nitrogen fertilization, variety and harvest date. Jour. Amer. Soc. Sugar Beet Technol. 10(7):624-630. 1959.
Worley, G.W., joint author. See under Henrickson.
Wright, H.B., joint author. See under Thoma.
779. Wu, T.C., D. Wittenberg, and H. Gilman. Addition of silylmetallic compounds to olefins. Jour. Organic Chem. 25:596-598. 1960.
_____, joint author. See under Wittenberg.

Yamamoto, S., joint author. See under Duke.
780. Yates, Norris W. The "counter-conversion" of Huckleberry Finn. Amer. Literature 32:1-10. 1960.
781. Yeh, M.H. and E.O. Heady. Why do we use "new practices"? Iowa Farm Sci. 14(4). 1959.
_____, joint author. See under Heady.
York, G.T., joint author. See under Smith, O.E.
782. Young, Donald F. Drag and lift on spheres within cylindrical tubes. Jour. Hydraulics Div., Proc. Amer. Soc. Civil Engr. 86:47-57. 1960.
783. _____. The coring phenomenon in the flow of suspensions in vertical tubes. Amer. Soc. Mech. Engr., Paper No. 60-HYD-12. 8 pp. 1960.
Youngquist, R.W., joint author. See under French.

Zaffarano, D.J., joint author. See under Holloway.
Zaweski, E.F., joint author. See under DePuy.
784. Zimmermann, D.R., V.C. Speer, V.W. Hays, and D.V. Catron. Injectable iron-dextran and several oral iron treatments for the prevention of iron-deficiency anemia of baby pigs. Jour. Anim. Sci. 18:1409-1415. 1959.
785. _____, V.C. Speer, V.W. Hays, and D.V. Catron. A comparison of intramuscular and intraperitoneal injection of iron-dextran. Jour. Anim. Sci. 19:484-486. 1960.
786. Zimmermann, W.J., E.D. Hubbard, and J. Mathews. Studies on fecal transmission of Trichinella spiralis. Jour. Parasitol. 45:441-445. 1959.
Zuber, M.S., joint author. See under Grogan.
Zuech, E.A., joint author. See under Gilman.
787. Zyskind, George and Oscar Kempthorne. Treatment errors in comparative experiments. Wright Air Development Division Technical Note 59-19. U.S. Air Force. 78 pp. 1960.